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ENGINEERING NEWS-RECORD

OCTOBER 18, 1945

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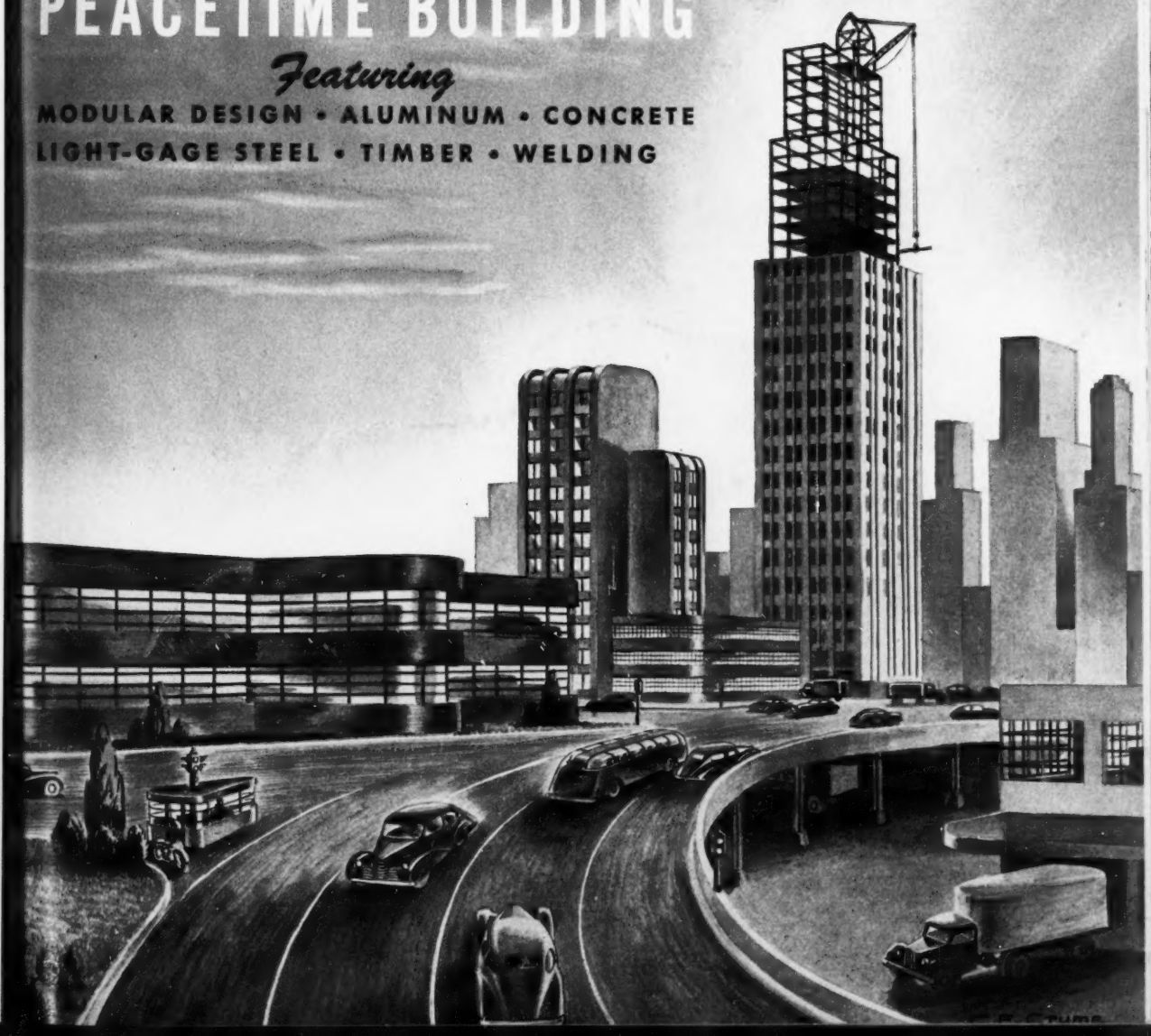

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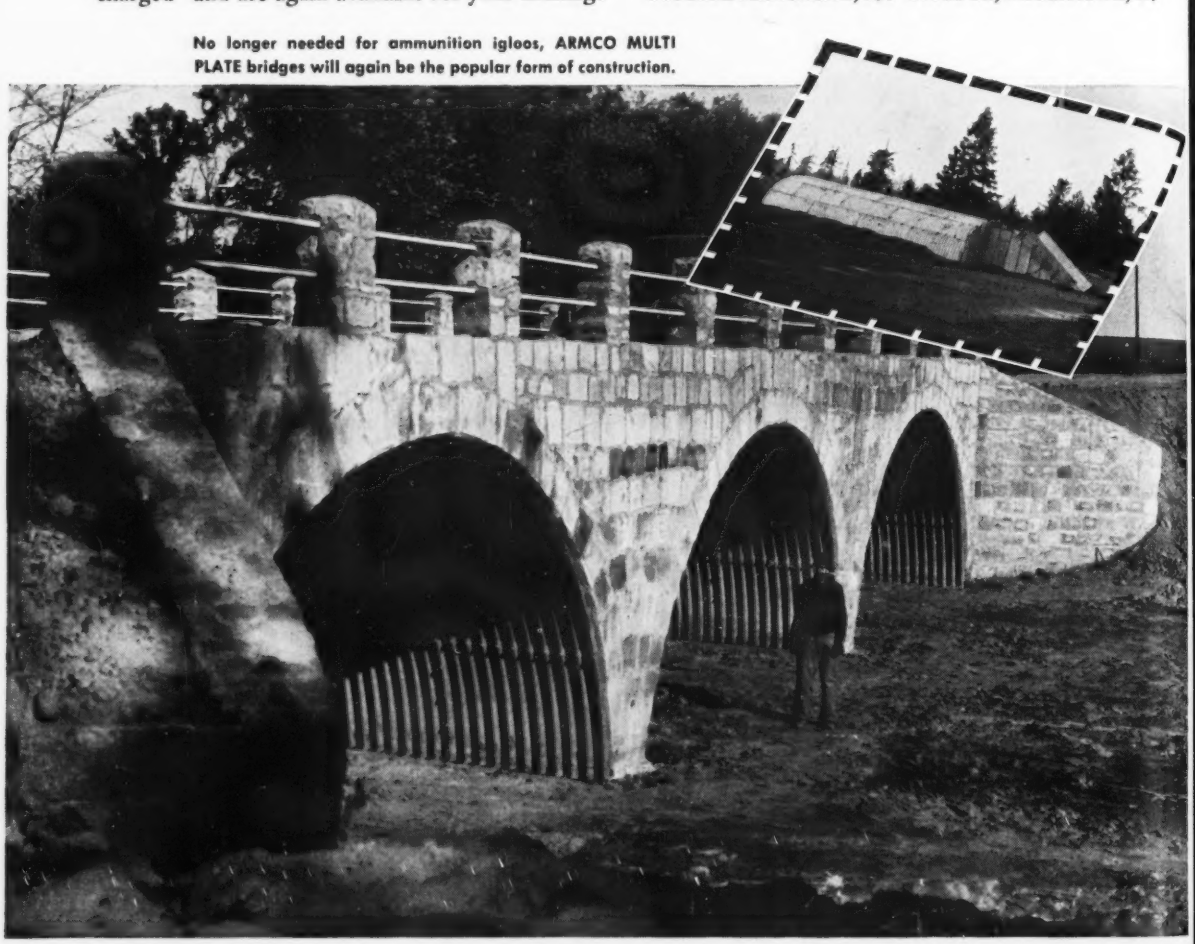

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McGRAW-HILL PUBLISHING COMPANY, INC.

Publication Office: 99-129 North Broadway, Albany 1, N. Y. • Editorial and Executive Offices: 330 West 42nd Street, New York 18

WALDO G. BOWMAN, *Editor* ALBERT E. PAXTON, *Publisher*

Vol. 135 OCTOBER 18, 1945 No. 16

COMING NEXT

Snow removal and ice control on state highway systems constitute an expensive public service—one which is taken for granted when it is good, yet quickly criticized when it is not. To help those charged with the responsibility of keeping our highways open this winter *ENR* will present in the Nov. 1 issue a special report covering current practices being employed by twelve state highway departments in widely separated sections of the snow belt.

In order to obtain concrete free from surface defects, engineers on the Norfork Dam project used a fabric-covered ¼-in. thick absorptive lining for forms at a cost of 12c. per sq. ft. When this material was backed-up with a non-absorptive lining a better surface was obtained and at a saving of 3½c. per sq. ft. over use of the material directly on wood sheathing. Methods of application and field experience with both types of lining will be outlined in an article scheduled for Nov. 1 issue.

Analysis of continuous structures is facilitated by the use of moment ratios, factors that permit one-cycle moment distribution. The first of two articles showing how these constants simplify the calculation of maximum bending moments will appear in the Nov. 1 issue.

LOOKING AHEAD

The new Pecos River railway bridge in southern Texas is a spectacular structure of continuous deck cantilever type, with a 375-ft. main span over a deep rocky gorge. The main is carried on hollow concrete piers, the tallest of which is 275 ft. These piers were built with slip forms, concrete being delivered by cableway, and the superstructure erection was by cantilever methods aided by jacking over the piers. The project will be described in an early issue.

Investigation of structural behavior of Fontana Dam is being carried on with the aid of special measuring instruments. Meters are installed across longitudinal and transverse joints to determine changes at contraction joints, to observe movements of adjacent blocks during grouting and to check subsequent changes. Installation and checking procedures will be described in a forthcoming issue.

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Number of copies of this issue printed: 39,754

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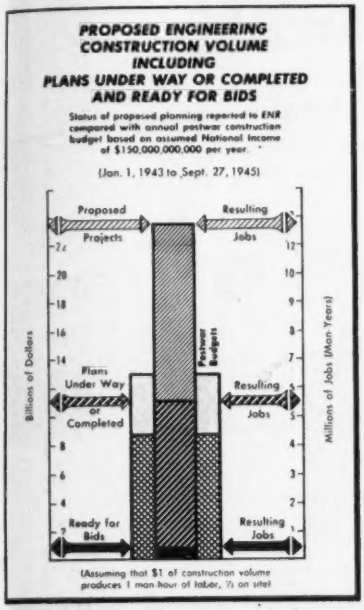
Future Construction Planning Report

THE RESERVOIR of identified and recorded engineering projects proposed for future construction totaled $23,672,516,000 as reported to *Engineering News-Record* in the 33 months from January 1943 through September 1945.


PROPOSED ENGINEERING CONSTRUCTION VOLUME INCLUDING PLANS UNDER WAY OR COMPLETED AND READY FOR BIDS
Status of proposed planning reported to ENR compared with annual postwar construction budget based on assumed National Income of $150,000,000,000 per year.
(Jan. 1, 1943 to Sept. 27, 1945)
Proposed Projects
Resulting Jobs
Postwar Budgets
Plans Under Way or Completed
Resulting Jobs
Ready for Bids
Resulting Jobs
Billions of Dollars
Millions of Jobs (Man Years)
(Assuming that $1 of construction volume produces 1 man-hour of labor, ½ on site)

Approximately 47 percent of the proposed backlog, $11,090,641,000, has engineering plans under way or completed.

Aided by the lifting of WPB restrictions on materials and easing of the manpower situation, $74,051,000 worth of proposed projects advanced from the future construction reservoir into active work during September. This brings the total to date to $120,589,000 for projects transferred from the reserve to the active stage. Of this cumulative proposed total, $80,689,000, or 67 percent was in the planning stage prior to advancement to active status.

During September $1,140,516,000 in new proposed projects and $795,106,000 in projects with plans under way or completed were added to the reservoir of future engineering construction. The proposed project total for the month is 59 percent above the 33-month average of $719,000,000, and the planning total for September is 136 percent above the monthly average for the period from January 1943 through September 1945, $336,000,000.

At the end of September, there were $971,015,000 worth of construction projects in the reserve total ready for bids, with all land, legal and financing obstacles overcome. In addition, projects valued at $608,179,000 have the planning completed but are held up by lack of financing, and $1,049,692,000 worth of projects have financing available but engineering planning unfinished.

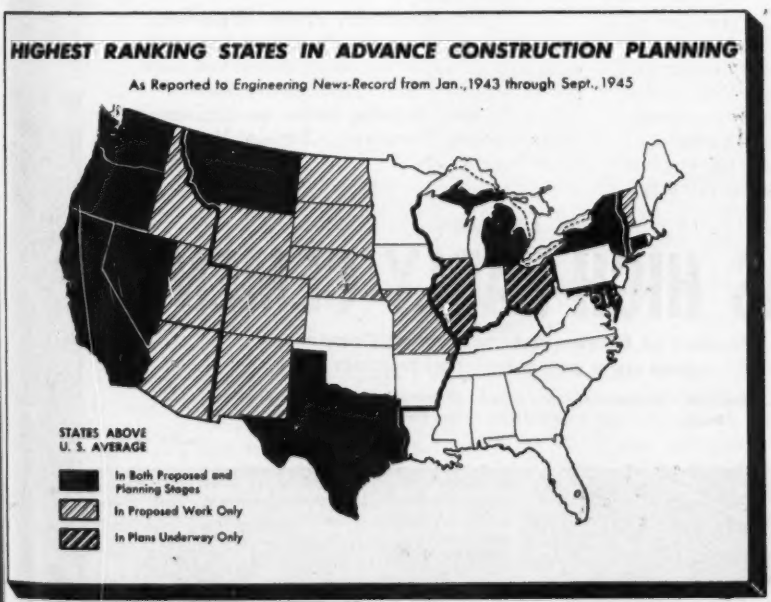
The project volume in the ready-for-bids stage is equivalent to an investment of $7.40 for each person in continental United States (1940 census).

Thirteen states and the District of Columbia top the $84.00 per capita planning stage average volume. Florida and Wyoming were reported in this group a month ago, but due to advancement of work to active status, they are now below the per capita plans average for the 33-month period.

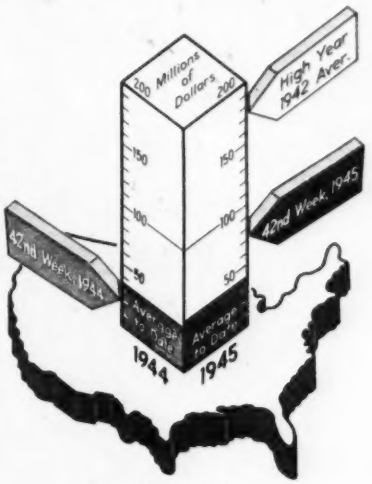
(*Proposed Project Reports, page* 174)

HIGHEST RANKING STATES IN ADVANCE CONSTRUCTION PLANNING

As Reported to *Engineering News-Record* from Jan., 1943 through Sept., 1945



CONSTRUCTION ACTIVITY



As Reported This Week to... *Engineering News-Record*

CONTRACT VOLUME

Continental U. S. Only (Thousands of Dollars)

	Week of Oct. 18 1945	Cumulative 1945 (42 wk.)	Cumulative 1944 (42 wk.)
Federal	$3,208	$687,581	$970,098
State & Mun.	12,794	288,542	210,077
Total Public	$16,002	976,123	$1,180,175
Total Private	57,079	701,149	304,407
U. S. Total	**$73,081**	**$1,677,272**	**$1,484,582**

WHERE CONSTRUCTION ACTIVITY ORIGINATED THIS WEEK

Type of Work	Dollar Volume (Thousands) This Week	Cumulative 1945 (42 wk.)	Cumulative 1944 (42 wk.)
Waterworks	$1,545	$42,380	$26,943
Sewerage	1,508	27,818	26,896
Bridges	4,149	32,364	12,677
Highways	4,481	182,261	170,722
Earthwork, Waterways	1,338	43,901	58,909
Buildings, Public	2,497	420,342	562,749
Industrial	21,985	422,948	143,547
Commercial	19,647	186,266	117,113
Unclassified	15,272	318,333	365,026

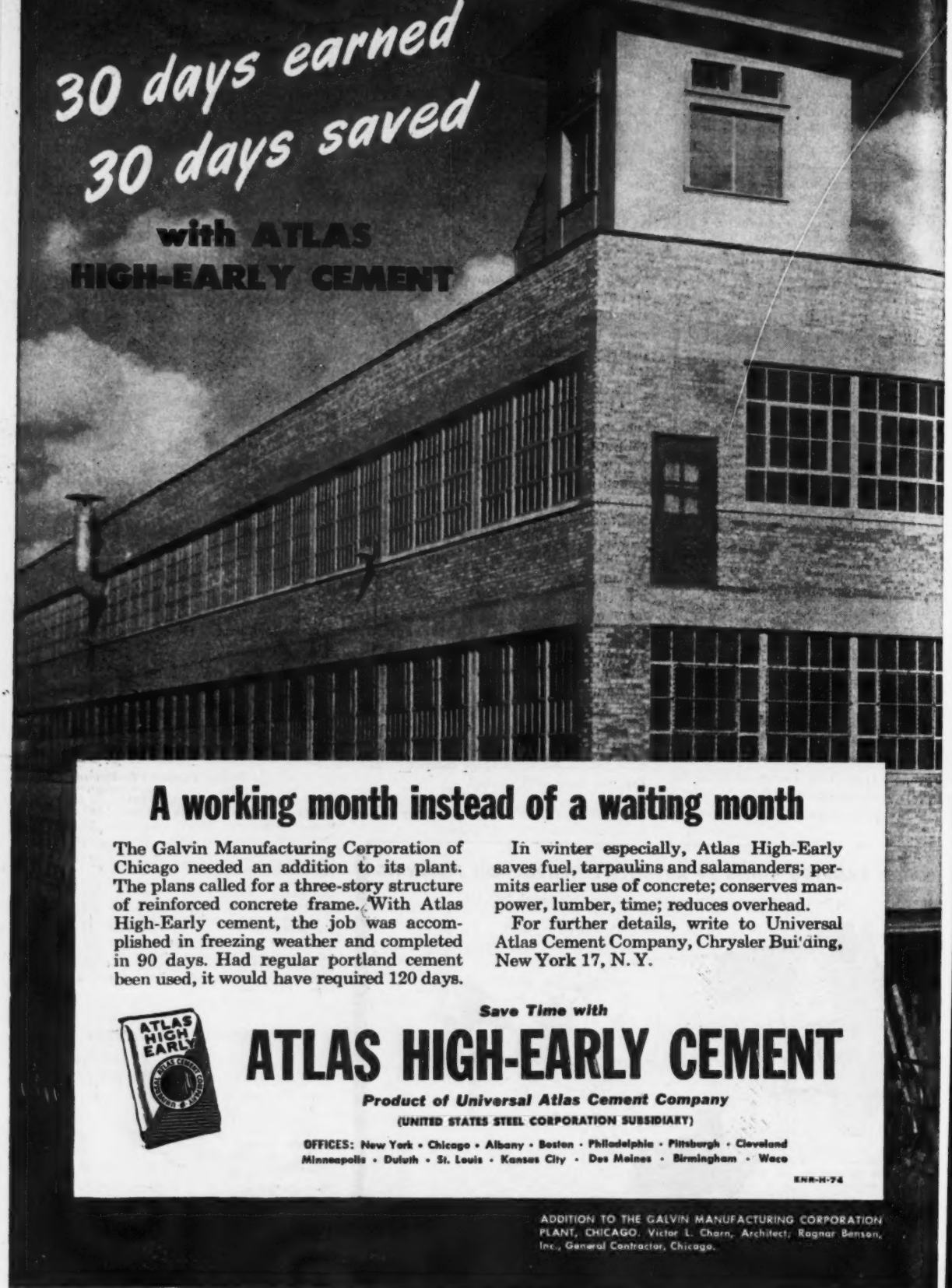
NOTE: Minimum size projects included are: Waterworks and waterway projects, $15,000; other public works, $25,000; industrial buildings, $40,000; other buildings, $150,000.

NEW PRODUCTIVE CAPITAL

	Cumulative 1945 (42 wk.)	Cumulative 1944 (42 wk.)
NON-FEDERAL	$651,779	$367,821
Corporate Securities	163,231	96,970
State and Municipal	324,948	129,911
RFC Loans	24,600	57,940
REA Loans	60,000	20,000
Fed. Aid Highway	79,000	63,000
FEDERAL	$1,049,898	$1,263,800
Total Capital	$1,701,677	$1,631,621

ENR INDEX NUMBERS

Index Base 100		1913	1926
Construction Cost	Oct. '45	309.28	148.67
Building Cost	Oct. '45	240.35	129.93
Volume	Sept. '45	164	72



A working month instead of a waiting month

The Galvin Manufacturing Corporation of Chicago needed an addition to its plant. The plans called for a three-story structure of reinforced concrete frame. With Atlas High-Early cement, the job was accomplished in freezing weather and completed in 90 days. Had regular portland cement been used, it would have required 120 days.

In winter especially, Atlas High-Early saves fuel, tarpaulins and salamanders; permits earlier use of concrete; conserves manpower, lumber, time; reduces overhead.

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ENR-H-74

ADDITION TO THE GALVIN MANUFACTURING CORPORATION PLANT, CHICAGO. Victor L. Charn, Architect; Ragnar Benson, Inc., General Contractor, Chicago.

SUNDAY EVENINGS—American Broadcasting Company (Blue) Network—U. S. Steel's "The Theatre Guild on the Air"

The Week In Engineering and Construction

ENGINEERING NEWS-RECORD • OCTOBER 18, 1945 • VOLUME 135 • NUMBER 16

Supreme Court decree concludes long litigation over North Platte waters

Court affirms earlier findings, discarding priority appropriation of water for system of percentages of natural flow in stream

A decree providing for the apportionment of the "natural flow" waters of the North Platte River among the states of Colorado, Wyoming and Nebraska was handed down last week by the U. S. Supreme Court. The decree places in force the findings of the court announced last June 11 in a 53-page decision (*ENR* June 14, vol. p. 809).

The action gives Nebraska the major share of the river's water, and restricts storage rights of Colorado and Wyoming.

The court order concludes eleven years of litigation that started in October, 1934, when Wyoming was charged by Nebraska with violating the rule of priority of appropriation—in force in the two states—thereby depriving Nebraska of water.

Colorado was brought into the case because the headwaters of the river are in that state, and in March, 1938, the United States intervened to assert a right for water for the North Platte and Kendrick projects of the Bureau of Reclamation.

Of most importance is the method adopted by the court for apportioning the natural flow of the river in the 42 mi. section between Guernsey and Tri-State dams between Nebraska and Wyoming. Instead of an interstate priority schedule for the Wyoming and Nebraska canals in this section, or a mass allocation of water on a seasonal basis—such as the court adopted in the Laramie River case—the natural flow as such is apportioned 25 percent to Wyoming and 75 percent to Nebraska on the basis of the daily flow.

In addition, Wyoming is enjoined from diverting water from above Guernsey and Pathfinder reservoirs for irrigation of more than 168,000 acres in that state during any irrigation season. The state is further restrained from storing more than 18,000 acre-ft. of North Platte water for irrigation purposes above Pathfinder Reservoir between Oct. 1 and the following Sept. 1.

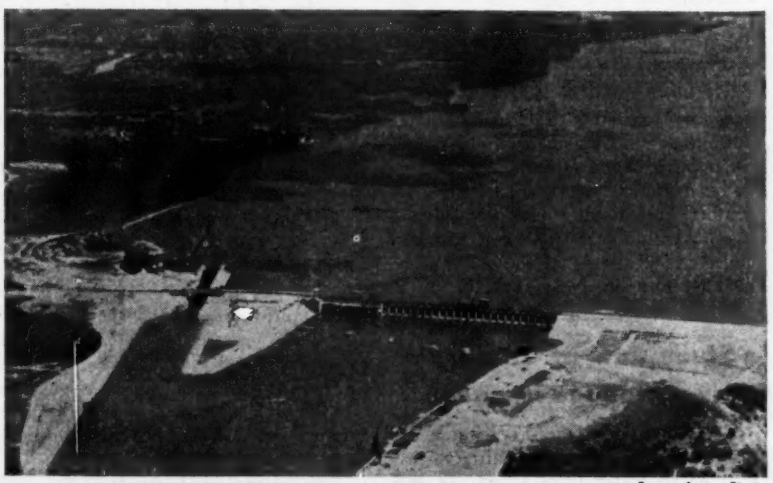
Wyoming must also store water in Pathfinder, Guernsey, Seminoe and Alcova reservoirs in a manner "to give priority to the reservoirs in the order named." However, water for generating electric power may be impounded in or released from Seminoe Reservoir contrary to this preference when such storage or release will not materially interfere with irrigation storage.

Nebraska storage is senior

A further restriction regarding storage in the four reservoirs named above is that Nebraska appropriations for the French, Mitchell, Gering, Tri-State and Ramshorn canals, which divert water from the river near the Wyoming-Nebraska boundary, were adjudged senior. However, to protect Wyoming, the court placed limitations on diversions in the canals, both as to peak flows and total diversion during the irrigation season.

Wyoming is also enjoined from diverting water from above Alcova Reservoir in lieu of or in exchange for return flow water from the Kendrick project reaching the river below Alcova Reservoir.

Colorado is enjoined from doing three things. These are: (1) Diverting North Platte water for irrigation of more than 135,000 acres in Jackson County during the irrigation season; (2) Storing more than 17,000 acre-ft. for Jackson County irrigation between Oct. 1 and the following Sept. 30 and (3) exporting out of Jackson County to any other stream basin more than 60,000 acre-ft. in any period of ten consecutive years beginning Oct. 1, 1945.



Press Assn. Photo

Kentucky Dam dedicated by President

Kentucky Dam, last link in TVA's great power, flood control and navigation system, located on the Tennessee River near Gilbertsville, Ky., was dedicated by President Truman on Oct. 10.

Completion of this dam was greatly expedited at the request of the War Production Board in order to produce power for the war effort at the earliest possible date. It was closed Aug. 30, 1944, and water in the reservoir reached a level sufficiently high to produce power through the first unit Sept. 14. The second unit went on the line Nov. 18, and the third April 6, 1945.

A fourth unit is expected to go into operation some time this fall, and a fifth unit was added to the plan by TVA after the end of the war, but is not expected to be completed until some time in 1946.

The reservoir work is being rapidly finished and will be completed in time to allow the impounding of water for maximum amount of flood protection this winter and in the spring of 1946.

ASA approves three building standards

The American Standards Association recently announced approval of three new standards in the construction industry, two of them affecting coordinated sizes and dimensions for building materials, and the third affecting requirements for minimum design loads in buildings and other structures. The minimum load ruling, known as "Standard Building Code Requirements for Minimum Design Loads in Buildings and Other Structures," (A58.1-1945), contains recommendations on strength requirements for floors and walls in factories, office buildings and theatres; on construction to resist wind pressure, earthquake shock and winter snow loads; and on similar problems.

As a result of work done, a method of reduction has been developed and incorporated in the standard. Essentially, this method consists of starting with a basic live load equal to the maximum to be allowed on any panel, and rapidly reducing to a minimum load based upon the relation of live and dead loads in such a manner that overstress on any member, due to full basic load throughout the structure, cannot exceed a predetermined value.

The two other standards are known as "American Standard Basis for the Coordination of Dimensions of Building Materials and Equipment," (A62.1-1945) and "American Standard Basis for the Coordination of Masonry," (A62.2-1945). Briefly, these standards are expected to eliminate much cutting and fitting on the job, reduce the number of sizes of building products to be manufactured and carried in inventory, and simplify design and detailing of buildings. Copies of the new codes are available at the ASA office, 70 East 45th St., New York, 17, N. Y.

Study flow of California rivers for sea inroads

To determine necessary water releases from Shasta Dam, Calif., to prevent ocean water from advancing into the Delta channels of the Sacramento-San Joaquin rivers, the first phase of an extensive water-measuring program has just been completed, Acting Regional Director R. S. Calland of the U. S. Bureau of Reclamation, has announced.

Working in close cooperation, the State Division of Water Resources, the Corps of Engineers, the U. S. Coast Guard, and the U. S. Bureau of Reclamation are making the surveys.

The joint Federal-State enterprise to obtain basic water information was initiated under the direction of Regional Water Master Martin H. Blote of the Reclamation Bureau, who said that previous office and field investigations by the State Division of Water Resources indicated that about 3,700 cu. ft. of water per second are consumed for irrigation and other purposes in the Delta area during July and August, the months of highest demand. The State's studies indicated also that a flow of 3,300 sec. ft. into the Bay at Collinsville is necessary to keep ocean water out of the Delta channels.

Unique control proposed for California river

Unique in that it departs from the conventional type of revetments and levees, a $2,000,000 flood control plan for the Salinas River, California, has been recommended by Brig. Gen. Philip G. Bruton, Pacific Division Engineer, Army Engineer Corps.

The plan depends largely upon the planting of willows and other vegetation, as well as flexible type revetments consisting of cables and jacks or tetrahedrons, lighter type flexible fences in some cases and other trash and silt collecting devices. The work would involve a 5-year program of bank protection, protective planting, channel clearing, and levee development.

Puerto Rico to build five new airports

Establishment of five major airfields in Puerto Rico was recommended recently to the Island Planning Board. The proposal includes the establishment of an international airport in Isla Verda, near the city of San Juan, and the establishment of an airport at Ponce, second largest city on the island. Other work suggested was acquisition and enlargement of the Mayaguez Airport and the transfer to the insular government of airports now in the hands of military authorities.

The international airport at San Juan would include ample facilities for international air travel, and construction of a modern airfield at Isla Verde, including rehabilitation of a naval plane base at Boca Cangrejos.

The Planning Board recommended that the Puerto Rico Transportation Authority be instructed to purchase necessary land and sites for construction of the international airport, and that the Department of the Interior be instructed to proceed with plans for the reconditioning of the Boca Cangrejos base.

Groves named assistant to Chief of Engineers

Maj. Gen. Leslie R. Groves, who was in charge of the construction of the atomic bomb production facilities for the U. S. Army (*ENR* Aug. 16, vol. p. 197), has been nominated by the President to be an assistant to the Chief of Engineers. The appointment, which must be approved by the Senate, is for a 4-yr. period with the permanent rank of Brigadier General. Groves now holds the permanent rank of Lieutenant Colonel.

Under the National Defense Act the Chief of Engineers is provided with two assistants, one to head civil works and the other military activities. For a time, Brig. Gen. John J. Kingman acted as assistant in charge of military operations, but shortly before Pearl Harbor he was named to head the Beach Erosion Board. During the war the Office of the Chief of Engineers was organized on a basis superseding the type of organization set up by the National Defense Act. Now, however, that office is making plans to operate with the set-up of two assistants.

One of these positions will be filled by General Groves, Lt. Gen. Raymond A. Wheeler, newly appointed Chief of Engineers and now on leave in this country, when he takes over active control of that office will designate which position Groves is to hold.

A 1918 graduate of West Point, General Groves has had a varied engineering experience. After serving in France during the first World War, he was graduated from both the basic and civil engineering courses of the Engineer School. Following assignments at Camp Lewis, Wash., with the 4th Engineers at Fort Worden, Wash., and at the Presidio of San Francisco in 1922, he was ordered to a 3-yr. tour in Hawaii with the 3rd Engineers.

He later served as assistant district engineer at Galveston, Tex., for two years and soon afterward went to Nicaragua to serve with the 1st Engineers on survey work. In 1931 he returned to the U. S. for duty in the supply section, Office of the Chief of Engineers, serving as chief of that section. Following graduation from the Command and General Staff School at Leavenworth in 1936, General Groves was named assistant engineer for the Missouri River division. Later he was graduated from the Army War College. In 1940 he became head of what became the Operations Branch, Construction Division, Quartermaster Dept.

From June, 1942, to August of this year General Groves was commanding general of the specially created Manhattan district, Army Service Forces.

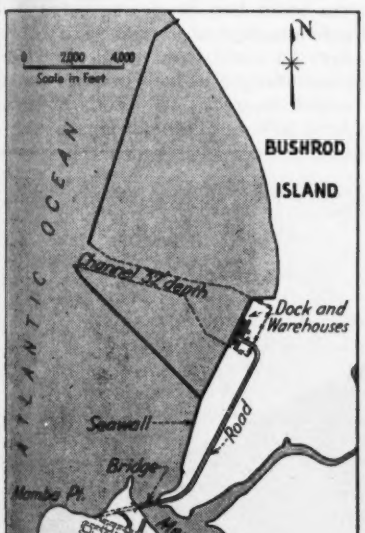
Navy building extensive Liberian port

Commercial port facilities estimated to cost $15,000,000 are now being constructed at Monrovia, Liberia, West Africa, under supervision of the U. S. Navy. The Raymond Concrete Pile Co., New York, is doing the work and operations have been under way for more than a year. Wartime censorship prevented previous mention of the job.

The entire project, which will provide a free, protected, deepwater port of sufficient size to accommodate 10,000-ton ships, is scheduled to be finished in 1947. Completion will eliminate the necessity of lightering all cargo to and from ships anchored in the open ocean near Monrovia, the republic's capital.

The port proper will be located on Bushrod Island across the Mesurado River from the city of Monrovia (see map). A 790-ft. trestle supported on steel H piles and having a concrete superstructure is being built across the river for construction purposes. When the port facilities have been completed, the deck of the bridge will be resurfaced and the crossing used as a permanent means of access from the city.

A reinforced-concrete marginal dock 2,000 ft. long and 48 ft. wide is planned to accommodate three to five ships at a time, depending upon their size. Port facilities will consist of permanent type



transit sheds, a custom house, administration offices, a tank farm, water supply facilities and an electric power plant, together with necessary roads and paving.

Two rock breakwaters will also be built to form an enclosed harbor approximately 1,460 acres in size. Their construction will require about 2,210,000 cu. yd. of rock, and explorations are now in progress west of Monrovia, at Mamba Point, to determine the most advantageous borrow location. An approach channel and turning basin are to be dredged to a depth of 32 ft. below mean low water, which is expected to require removal of about 3,000,000 cu. yd. of sand.

The port will facilitate exportation of rubber, palm oil and other products and importation of necessary supplies to develop the natural resources of the country—including iron ore, precious metals and timber. The project is expected to result in mutual benefit to Liberia and the United States. Foreign Economic Administration scientists and health engineers are now in Liberia studying the best methods of developing that country.

The agreement under which the facilities are being built was approved by this country June 8, 1943. Under it, the U. S. is financing the construction and is to be reimbursed by revenues derived from operation of the facilities. A private operating company will administer the port until its cost has been repaid, when control will pass to the republic.

Later, a system of access roads from the port to the interior may be constructed. Although Liberia is about the size of the state of Ohio and has a population estimated at about 2,000,000, it now has only 200 miles of highways.

Vice Admiral Ben Moreell, CEC, USN, Chief of the Bureau of Yards and Docks, is in charge for the U. S. Navy. The work is under the general direction of Capt. Kirby Smith, CEC, USNR, head of the construction department of the bureau, and Capt. E. B. Cary, CEC, USNR, is officer in charge of construction work at the port.

Push preliminary work for Angostura Dam

The Bureau of Reclamation is now carrying on final preparatory work for the construction of Angostura Dam on the Cheyenne River, southeast of Hot Springs, S. D.

Construction is expected to start early in 1946. The structure, an irrigation and flood control project, will consist of a concrete overflow section across the Cheyenne River channel and an earth dike on the right abutment. The overflow section will be of the gravity type, with five radial gates 50 ft. long and 30 ft. high. Maximum height of the proposed dam will be 153 ft., with a crest length of 1,775 ft. Total capacity will be 150,000 acre-ft., with an active storage of 92,000 acre-ft.

Other features of the project include a main canal 25 miles long on the south side of the Cheyenne River, crossing the river and a small creek by means of a 9,635-ft. siphon. The job will serve to irrigate 16,100 acres of land.

States reject rising unit bid prices

Additional evidence that the factors of uncertainty of material supply and labor costs may prove a serious block to construction plans for the immediate future was supplied by a survey last week.

Engineering News-Record's Business News reports show an increasing percentage of bids rejected, presumably due to bids higher than current materials price and hourly wage rate trends would appear to justify.

Comment on the trend was highlighted by H. O. Schermerhorn, acting chief engineer, New York State Department of Public Works. Explaining the state's recent troubles in obtaining bids on highway work (*ENR* Oct. 11, vol. p. 465), Mr. Schermerhorn said:

"Present uncertainties regarding price of labor and materials have prompted bidders to submit prices secure against all eventualities. Contractors are interested and take out copies of proposals, but fail to file bids.

"The state's estimates have been raised 15 percent above 1940—thus allowing a legal bid about 35 percent above average bid prices for 1940." The liberalization, however, apparently has not proved sufficient incentive.

The *ENR* business reports covering September and the first half of October show the trend to reject bids extending to almost every construction category. A breakdown of the figures shows:

Forty-nine highway jobs, for a total of 150 miles, rejected and up for readvertisement in eight states; four highway jobs on which no bids were received; sewage-work jobs in six states on which bids were rejected; and public and private buildings in almost every state that have been held up for lack of bids or for bids that were too far over the engineers' estimates.

CONSTRUCTION IN CANADA

Plan $2 million road in Alberta—Grand River Commission to build new dams—Service men released for construction

The Canadian federal government and the Province of Alberta last week reached an agreement covering final arrangements for construction of a new highway northward from Grimshaw, Alta., to Hay River on the Great Slave Lake.

The new road will be 405 miles long, 300 miles of it within Alberta, and the remaining 105 miles in the Northwest Territories, which are administered by the federal government. Grimshaw is located on the Northern Alberta Railway, 333 miles northwest of Edmonton. Hay River is a small settlement on the southwest corner of Great Slave Lake.

The federal treasury will bear the entire cost of construction within the Northwest Territories, and half the cost within Alberta.

It is planned to clear right-of-way this winter and bring in heavy construction equipment before the spring thaw so that construction can start early next summer. The road will cost an estimated $2,000,000, and its completion will simplify movement of supplies to the Yellowknife district on the north shore of Great Slave Lake, location of a current gold mining boom.

The Grand River Conservation Commission, eastern Canada's first river control authority, is planning construction of three more dams and a scenic highway through the Grand River valley in Ontario.

Although the dams will be smaller than Shand Dam, completed by the commission in 1942 (*ENR*, Aug. 20, 1942, vol. p. 263), they will be fairly large structures, located on the Conestego and Nith Rivers, and at the exit to the Luther Marsh, drained some years ago to provide additional farm land and now to be re-flooded.

The proposed highway would extend from Port Maitland on Lake Erie to Dundalk in Grey County, where it would connect with the existing Blue Water scenic highway.

Adoption of a policy of immediate discharge, or granting of leave without pay, for all servicemen in military camps in Canada with experience in the building trades, was announced by Canadian National Defense headquarters at Ottawa recently.

Movement of several thousand skilled servicemen into the building industry, which is facing a serious manpower shortage, is expected to take place in the near future under this order. House building, in particular, will be assisted, this being Canada's number one construction job at present.

Applicants will be sent, with transportation paid, to the nearest office of National Selective Service or to such other district as desired. The National Selective Service undertakes to find jobs in the construction industry for all men thus released.

Completion near on French super-highway

A new super-highway, designed to provide a more direct and speedy link between Paris and the French provinces of Brittany and Normandy, is now nearing completion. The French press and information service further said that unless industrial shortages interfere, the road should be completely open to traffic within six months.

The new route is a part of a general highway plan laid out in 1905 when French engineers took up the problem of combining certain picturesque but narrow roads with miles of broad modern highways.

Novel low-cost housing development for Boston

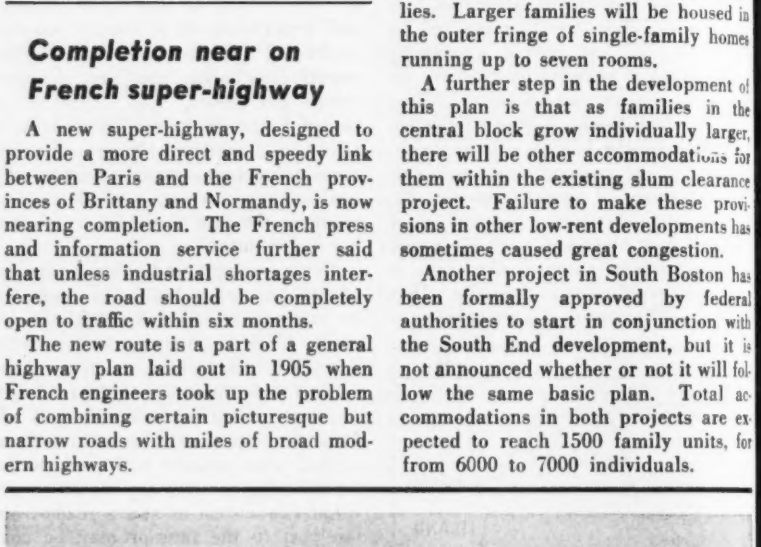
Construction of New England's first low-rent, elevator equipped public housing project for slum families will be started in the South End of Boston, Mass., within 90 days, according to an announcement of John Carroll, chairman of the Boston Housing Authority.

Designed "like a circus tent" with a 13-story structure in the middle, and working gradually down to an outer fringe of single-family 2-story dwellings, the 504-family project is the result of many conferences of local and federal housing authorities.

The 13-story central building will contain 3-room apartments for small families. Larger families will be housed in the outer fringe of single-family homes running up to seven rooms.

A further step in the development of this plan is that as families in the central block grow individually larger, there will be other accommodations for them within the existing slum clearance project. Failure to make these provisions in other low-rent developments has sometimes caused great congestion.

Another project in South Boston has been formally approved by federal authorities to start in conjunction with the South End development, but it is not announced whether or not it will follow the same basic plan. Total accommodations in both projects are expected to reach 1500 family units, for from 6000 to 7000 individuals.



Press Assn. Photo

Floods cause collapse of old covered railroad bridge

One of the few remaining covered railroad bridges in the United States, this 55-year-old structure at Franklin Junction, N. H., collapsed into the Merrimack River during recent floods. Built in 1890, the hand-hewn oak structure had a 200-ft. span, and carried the single track of the Franklin-Tilton Railway until 1936, when footings were weakened and the bridge abandoned. The north end of the bridge fell about 40 ft. into the river when the stone abutment on that side collapsed Sept. 21.

Plan reorganization of Cleveland transit system

A complete revision and reorganization of the city-owned transportation system at Cleveland, Ohio, is envisioned in an engineers' report submitted to the city transit commission recently.

The report, the result of six months of surveys and studies, was prepared by the firm of DeLeuw, Cather & Co., Chicago consultants.

Total cost of the project, which would include extension of existing surface-rail tracks, construction of a downtown subway, and purchase of new rolling stock and buses, is fixed at about $40,000,000.

In brief, the following steps were recommended:

(1) A rail rapid transit system, utilizing the construction work done years ago by the Nickel Plate Railroad and Cleveland Terminal Co., would be completed and placed in operation to extend from Cleveland's east side at Windemere and Euclid Aves. to the west side at 110th St. near Detroit Ave., a distance of 14.5 miles; (2) construction of a downtown subway, from a point where East 14th St. meets with the Nickel Plate Railroad tracks, under 14th St., northward to a point where Huron Road and Euclid Ave. meet, then westward under Huron Road to the terminal building, a distance of 1.52 miles; (3) elimination of all street cars, and replacement with buses and trackless trolleys; (4) establishment of express bus lines in certain areas.

West Coast pushing sewage disposal

Municipal administrators and sanitary engineers are working overtime on the Pacific Coast to take care of sewage disposal problems caused by population increases and obsolete systems.

Most projects are beyond talking stage with a few having workmen already on the job. Financing in many instances is dependent on local taxes plus state aid, but bonds are proving the most common method of raising funds where large amounts are involved.

Some projects are of long standing with manpower and material shortages responsible for postponement during the war. Sewer needs being met range from immediate, as in Los Angeles where miles of beaches are quarantined due to pollution (caused by unscreened sewage emptying near the shore through a broken outfall pipe), to long-range planning as in Spokane, Wash., where the city's estimated population needs for 1995 are being considered.

Additions to the survey of western sewers already reported (*ENR*, Sept. 27, vol. p. 402) finds San Francisco ready to launch its $12,500,000 project for which bonds have already been voted, and Los Angeles dipping into the city's reserve fund for a $2.000,000 loan to get started on $21,000,000 worth of repairs and improvements. Although Los Angeles citizens voted $10,000,000 in bonds last April and surrounding cities using the system expect to contribute $5,000,000, the remainder is still not in sight.

In San Diego, Calif., $1,879.000 is in the city treasury and immediately available for expanding sewage disposal facilities.

From accumulated reserves and a bond issue, Oakland, Calif., has earmarked $8,500,000 for its sewage disposal program, while neighboring Berkeley plans to spend $200,000 for outfall sewer work.

Part of a $7,000,000 fund for public works in Sacramento, Calif., will go for a new sewage treatment plant.

Salt Lake City, Utah, is just starting to prepare plans for sewers and a treatment plant estimated to cost $3,820,000, while in Cheyenne, Wyo., State Sanitary Engineer William V. Leonard has proposed that that city's inadequate sewage disposal system be replaced with a new $250.000 plant.

Treatment facilities costing $800,000, ten miles of connecting lines costing $2,800,000 and $200,000 for right-of-way and engineering make up the $3,800,000 project planned by Spokane, Wash. The city is asking the state for $1,000,000 to help in financing.

Other plans listed

The Board of Public Works and Safety, South Bend, Ind., has executed a contract with Consoer, Townsend & Associates, of Chicago, to make plans for sewage disposal improvements and to supervise construction.

Cost of the proposed improvement has been placed at $4,000,000; of this amount, $2,200,000 will be spent for an interceptor sewer system.

Work already done by the city toward construction includes the engineering of approximately $100,000 worth of interceptor sewers and information obtained by the city engineer's department under the direction of Clyde E. Williams as to river flow and other facts pertinent to the construction of the disposal works. Some $200,000 worth of sewers already have been built for the system.

Plans for an enlarged sewer system for the proposed sewage disposal plant at Hillsdale, Mich., are being requested by the city. For some time past the city has been faced, not only with the problem of providing a sewage disposal plant in compliance with state requirements, but also to enlarge the present sewer system.

The San Francisco Board of Supervisors has approved an increase in water rates amounting to about 17½ per cent to users within the city limits.

U. S.-Mexico water treaty approved by Mexico

The Mexican Senate recently approved by unanimous vote ratification of the treaty with the United States relating to the waters of the Rio Grande, Colorado and Tijuana rivers.

The Mexican legislative group appended no reservations whatsoever to the agreement, simply endorsing the treaty in the form approved last April 18 by the U. S. Senate (*ENR* April 26 vol. p. 596). Although several reservations were proposed before the U. S. Senate voted, the treaty as finally approved was free of all reservations. However, the U. S. Senate resolution of approval did include interpretations intended to clarify certain provisions with respect to controversial questions between the two nations.

Before the treaty can become effective it will be necessary for the presidents of both countries to ratify the agreement. After this has occurred, only an exchange of diplomatic ratification notes will be needed to put the treaty, (*ENR* Jan. 25, vol. p. 123,) into effect.

H. P. Coloney new head of Florida road engineers

Capt. Herndon P. Coloney, of St. Petersburg, Fla., a former Florida State Road Department assistant engineer, who headed Navy Seabee units in the South Pacific, has been appointed chief of the Florida highway engineer staff, effective Nov. 1.

Succeeding J. H. Dowling, who has resigned as chief engineer after 20 years service, Mr. Coloney left the department in 1938 for active duty as a junior grade lieutenant in the Naval reserve. He served as assistant public works officer until Sept. 1941, at the Pensacola Naval Air Station, where he supervised construction of Suafley and Ellison fields and much of the construction at the main station.

Later, Captain Coloney became commander of the Fifth Naval Construction Regiment at Espiritu Santo in the South Pacific. In December, 1944, he was transferred to the staff of the commander of construction troops at Pearl Harbor and took part in the planning of the Okinawa invasion.

WASHINGTON HIGHLIGHTS

Senate approves St. Lawrence bridge—District of Columbia launches bridge program—Navy to complete $9 million laboratory

The Senate last week passed a bill (H.R. 476) creating the St. Lawrence Bridge Commission and authorizing the commission to construct a bridge across the St. Lawrence River at Ogdensburg, N. Y. The Senate also passed four other bills authorizing bridge construction on navigable streams. These are: S. 927, permitting Montana to construct a free highway bridge across the Missouri River at Poplar, Mont.; S. 1219, authorizing St. Francisville, Ill., to construct a toll bridge across the Wabash River at St. Francisville; H. R. 3150, authorizing Duluth, Minn., to construct a toll bridge across the St. Louis River between Minnesota and Wisconsin; and H. R. 3373, authorizing the reconstruction of the Spring Common Bridge on Mahoning Ave. across the Mahoning River near Youngstown, Ohio.

The Public Roads Administration has approved the use of plans or drawings reduced to one half the dimensions of the original plan for all federal-aid projects. Any of the normal processes of reproduction will be acceptable. In the past plans were required to be flat sheets 22 by 36 in., outside dimensions. An exception was bridge plans, which were restricted to the same width but could be any length.

The District of Columbia recently launched its postwar bridge and highway program when the office of H. C. Whitehurst, director of highways for the district government, awarded a $2,487,590 contract to Spencer, White & Prentis, New York, for the substructure for a new bridge across the Anacostia River. Known as the South Capitol St. project, the entire job is expected to cost $4,500,000. The structure will be of plate girder construction with the main crossing 854 ft. long, including a 386-ft. wing span at the main channel. The north approach will be 1,400 ft. long and on the south bank about 1,300 ft. of ramp will be required, including that needed for a semi-cloverleaf. When the work is completed, two 24-ft. roadways separated by a 4-ft. median strip and two 6-ft. sidewalks will be provided.

The Navy has approved the allocation of $9,519,000 to complete the Naval Ordnance Laboratory now under construction at White Oak, Md., near Washington, D. C. This decision assures the Navy of one of the most modern research and development centers in the country. Total cost of the project, including equipment, will approximate $15,000,000. Remaining to be constructed are the main laboratory building, auditorium, mechanical test building, shop, another warehouse, and miscellaneous structures.

A resolution (S.J. Res. 105) has been introduced in the Senate to permit the Corps of Engineers to proceed with a long list of previously authorized river and harbor projects. The resolution would amend the river and harbor act authorizing the projects (*ENR* March 1, vol. p. 287) by removing from the act the restriction that no project therein authorized could be constructed until six months after the termination of the war.

Engineers raise river to free stranded barge

In order to free a large oil barge stranded sidewise in the Columbia River at Celilo Falls near The Dalles, Ore., Grand Coulee Dam engineers on Sept. 19 released more than 12,000,000,000 gals of water to raise the level of the river a few feet 400 miles away.

The beached barge, owned by the Inland Navigation Co., broke its moorings at the entrance to the canal which by-passes the rapids. By means of huge jacks it had been pushed over the falls but it wedged in the channel as it was being guided by towlines into smoother water.

The Army Engineers in Portland asked the Federal Bureau of Reclamation for the extra water to free the barge. Farmers posted guards along the rising stream and anchored irrigation pumps and floating docks more firmly, while the engineers spread an emergency warning along the entire length of the river.

JOBS OF THE WEEK

LABORATORY, White Oaks, Md.

Bureau of Yards & Docks, Navy Departments, Arlington, Va., received the lowest bid for explosives laboratory, at Naval Ordnance Laboratory, from Charles H. Tompkins Co., Washington, D. C. at $4,848,000. Eggers & Higgins, New York, N. Y., and Taylor & Fisher, Baltimore, Md., are the architects.

RESIDENCES, San Leandro, Calif.

Valley & Lincoln Co., San Leandro, will build 400 residences and a shopping center, by its own forces. The estimated cost is $3,500,000.

OFFICE BUILDING and ADDITIONS, Houston, Tex.

American Construction Co., Houston, has been awarded a contract for two 10-story office building additions and a 2-story office for Humble Oil & Refining Co., Houston, at an estimated cost of $2,100,000. K. Franzheim-Staub-Rather Associates, Houston, are the architects.

POWER PLANT, Venice, Ill.

Stone & Webster Engineering Corp., New York, N. Y., will design and construct third unit of No. 2 power plant for Union Electric Co., St. Louis, Mo. The estimated cost with equipment is $9,000,000.

STEEL PIPE LINE, Texas

Gulf Refining Co., (Pipe Line Division), Houston, awarded a contract to Oklahoma Contracting Co., Dallas, for 123 miles of steel pipe line from Midland to San Angelo, at $2,091,000; 120 miles steel pipe line from San Angelo to Lampasas to J. R. Horrigan Construction Co., Houston, at $2,030,000; 230 miles steel pipe line from Lampasas to Port Arthur to Associated Contractors & Engineers, Houston, at $3,910,000.

FACTORY, Kankakee, Ill.

B. W. Construction Co., Chicago, has been awarded a contract for a 1-story, 300x1,200-ft. factory, office and power plant for A. O. Smith Corp., Milwaukee Wis. The estimated cost is $2,000,000.

MOTION PICTURE STUDIOS, New York, N. Y.

Pathe Industries, Inc., New York, N. Y., awarded a contract for altering studio and constructing building for shops to Diesel Electric Co., Inc., New York, at an estimated cost of $1,000,000. M. M. Glass and Mayer & Whittlesey, New York, are the architects.

Note—Additional bidding and contract news on many projects large and small, including the above items, appear in the Construction News section beginning on page 247.

OBITUARY

Claude C. Votapka, 46, member of the staff of government engineers, Onawa, Ia., died Oct. 3. He was well known among engineers working on the Missouri River, having been stationed formerly at Kansas City, Mo., and Nebraska City, Neb. A World War I veteran, he was graduated from the 1921 engineering class at the University of Nebraska.

Albert A. Dunn, 85, head of Dunn Brothers, Indianapolis, Ind., died Oct. 2. Mr. Dunn had specialized in church building construction. He had operated the firm 25 years with his brothers, James O. Dunn and George E. Dunn.

Otto J. Vanek, 58, a structural engineer, died Oct. 9 at Cleveland, Ohio.

Lieut. Ivan C. Bissell, 42, U.S.N.R., died Oct. 2 at the Brooklyn, N. Y., Naval hospital. Lieutenant Bissell was a former Akron, Ohio, construction engineer.

Harry T. Capell, 72, former president of Oregon Building Congress, died in Portland Oct. 8. He had been a contractor in Portland since 1906, a member of the building code appeal board and an officer of the Master Builders Association.

Samuel D. Bryden, engineer in the maintenance division of the Boston Elevated Railway for 40 years, died Oct. 6.

Arthur W. Calver, 66, civil engineer, died Oct. 2, at Newton, Mass. He was a graduate of Worcester Polytechnic Institute, and had been with the U. S. Coast and Geodetic Survey, working on the design for the Roosevelt Dam.

Daniel T. Hanley, retired city engineer at Cambridge, Mass., died Oct. 5.

Edward E. Welch, 57, Sacramento, Calif., planning and traffic engineer, died Oct. 5 in the Veterans Hospital in Yountville. He entered the employ of the city in 1923, as an engineer for the filtration plant. Later he became traffic engineer, and in 1943 he became planning engineer.

George F. Grunau, 56, veteran engineer for the city of Cleveland, Ohio, and for the last six years a civil engineer for the Ohio State Department of Highways, died Oct. 7. A graduate of Ohio Northern University and a veteran of World War I, he spent most of his engineering career in public service in and around Cleveland.

George T. Waite, 82, retired civil engineer and a resident of Berkeley, Calif., for 36 years, died Oct. 7. He had specialized in railroad bridge engineering work.

Alex F. Powell, 52, of Whiteville, N. C., former member of the North Carolina Highway and Public Works Commission and former town commissioner at Whiteville, died Oct. 2.

John M. Snyder, 86, a retired builder who took part in the development of the Tioga and Olney sections of Philadelphia, Pa., died Oct. 9.

Joseph B. McCormick, 79, pioneer construction engineer in the Southwest and Mexico, died at Tucson, Ariz., Oct. 3.

Robert E. Barrett, Sr., 64, civil engineer and a leader in the public utilities field in New England, died Oct. 13 in Holyoke, Mass. A native of Framingham, Mass., and graduate of Harvard, 1905, Barrett in 1907 became associated with the Catskill water supply system of New York City and in 1913 resigned to accept the newly established position of designing engineer for the Massachusetts commission known as the Directors of the Port of Boston. He later became chief engineer on the construction of the Commonwealth Pier in Boston, and in 1917 was appointed construction engineer for the Turners Falls Power and Electric Co. In 1920 he began his connection with the Holyoke Water Power Co.

G. H. Miehls named head of Kahn organization

George H. Miehls, formerly acting administrative head of the organization, has become president of Albert Kahn Associated Architects and Engineers, Inc. He succeeds the late Louis Kahn, who died Sept. 1.

A civil engineer, Mr. Miehls has spent his entire business career with the Kahn organization, joining it in 1919 after wartime service with the 23rd Engineers. Beginning as a construction engineer, he later became project manager on some of the large war plants built during the past several years, by the Albert Kahn organization.

G. H. Miehls

NEWS IN BRIEF

In telegraphic form, here are further news developments on the engineering and construction front during the week.

PRIVATE CONSTRUCTION—**Pan-American World Airways** applied for lease of 50 acres at San Francisco Airport to construct a $7,000,000 headquarters building. . . . **Peter Fox Brewing Co.,** Chicago, announced it will build a $2,000,000 plant in Cicero, Ill. . . . Construction work on a $1,500,000 **General Motors** assembly plant at South Gate, Calif., is under way, with Swinerton and Walberg Co. as general contractors. . . . **Pittsburgh Plate Glass Co.** announced plans to build a $500,000 addition to its Keene, N. H., plant. . . . **Hercules Powder Co.** said it was about ready to start work on a $1,500,000 plant at Burlington, N. J.

WATER SUPPLY—Flaws have been discovered in the new $294,000 water filtration plant at **Adrian, Mich.,** when earth fill under the concrete floor of the settling basin was washed away during recent test runs. . . . **Philadelphia, Pa.,** awarded a $1,127,244 contract to Ralph S. Herzog, Philadelphia, for additions and alterations to the city's Torresdale pumping station. . . . **Youngstown, Ohio,** appropriated $6,000 for employment of an engineering firm to survey the municipal water distribution system and recommend improvements. . . .Prechlorination, employing the "breakpoint" technique, will be adopted by **Cincinnati, Ohio,** soon, with better control of algal tastes and odors expected to result. Carl F. Eberling, waterworks superintendent, will direct the installation. . . . The **Lockport, N. Y.,** Common Council has received petitions recommending that the city prepare plans for a new water supply system, utilizing federal funds. . . . **Kendallville, Ohio,** is considering a half-million gallon standpipe and a water-softening plant. . . . **Rochester, N. Y.,** has been granted permission by the state Water Power and Control Commission to proceed with a $2,500,000 project to increase its supply.

HIGHWAYS—The **State of Maine** announced it had $5,870,264 with which to match federal highway-aid funds, and was proceeding with plans on that basis. . . . **Arizona,** planning an $8,800,000 program to be started before next June 30, called its highway engineers into session at Phoenix. . . . **Portland, Ore.,** took first steps to obtain money from the federal government for a $2,000,000 grade crossing elimination project.

Comment and Discussion

Readers' opinions on matters that concern engineers and contractors

Cascade Tunnels

Sir: Some of your readers may have wondered at the estimated costs of the two Cascade Mountain tunnels briefly described in *ENR* June 28, vol. p. 876. That of the Naches Pass —not Chinook Pass—tunnel with approach roads is stated to be $15,000,000. That of the 29-mile low-level tunnel is given as "about $40,000,000." This disparity probably results from origins. The State Highway Department investigated the Naches Pass project a couple of years ago. The low-level tunnel project is based chiefly on emotionalism.

In 1909 the late General H. M. Chittenden, U.S.E.D., called attention to the fact that along the route of the Great Northern Ry. across the Cascades it would be possible, between Skykomish and Leavenworth, to have a low-level tunnel only 1,000 ft. above sea level and suggested the construction of such a tunnel at some time in the future. Under the conditions then prevailing the idea had a warrant and value which the subsequent development of the modern motor vehicle, modern highways, modern snow-fighting equipment has largely destroyed. Its present advocates seem obsessed with the idea that if only the Cascades can be crossed at about this low level instead of at the 2,500 ft. to 3,000 ft. elevations of present rail and highway routes, tremendous benefits will result regardless of tunnel costs, accessibility, adverse mileages, or anything else. Moreover they apparently feel that any claims or assertions in behalf of this project are thereby justified and are relieved of the normal necessity of conformance with fact. This is exemplified in your own brief news dispatch.

Regarding the 29-mile length of tunnel between Skykomish and Leavenworth, the repeatedly-stated tunnel portals, the distance is actually 34 miles, not 29 miles.

Regarding shortening "the present route between Seattle and Eastern Washington by 70 miles"—by 81 miles, it was recently stated locally—it is to be said that only a 15-mile saving can actually be effected, since the present rail distance, Skykomish to Leavenworth, is but 49 miles and the direct tunnel distance is 34 miles.

Regarding the "about $40,000,000" cost—recently "about $30,000,000" locally—of what has been expressly stated to be a double-track, electrified railway tunnel through which motor vehicles will be ferried on railway cars, there is this pertinent evidence. When the Great Northern reconstructed and electrified their line through the Cascades in 1925-29 their published costs were $25,000,000 for the entire project, $14,000,000 for the single-track tunnel 7.79 miles long. And now a double-track tunnel, nearly 4½ times as long, at about 1,800 ft. lower elevation and with present day prices is to be built for "about $40,000,000!"

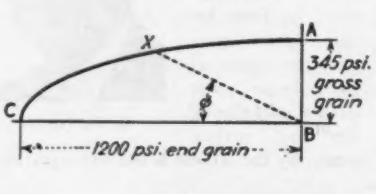
Similarly with respecting various other claims made for this project. The reader may wonder what the State of Washington will get for $100,000 spent investigating it. That is a good question; what will it get for its money?

HOMER M. HADLEY
Regional Structural Engineer
Portland Cement Assn.
Seattle, Wash.

Hankinson Formula

Sir: I read with interest the article by F. C. Smith dealing with the Hankinson formula and stresses at timber joints (*ENR* July 12, 1945. vol. p. 50). I prefer a graphic method and I wonder if the mathematicians can find anything wrong with the following:

Graphically let A-B be the maximum bearing in cross grain and C-B the maximum bearing on end grain:



These are naturally perpendicular to each other. The only curve that will pass through both of these points and also be perpendicular to the two axes is an ellipse, one quarter of which is A-C. This line A-C represents the maximum bearing at any angle measured from point B to the curve. With this assumption any bearing from end bearing to cross bearing can be read by laying the angle on the diagram and measuring the distance BX.

This method can be made even simpler by drawing the quarter ellipse on a piece of celluloid or other transparent material, then placing it directly over the joint in question and scaling the answer on the angle line.

Naturally these bearing values deal with only one grade and type of wood. Other ellipses are necessary for woods with different end- and cross-bearing values.

W. FRANCIS PARSONS
Architect-Director
Kern County, Calif. Building Department

Prestressed Concrete Design

Sir: The article on prestressed concrete design by Henri Marcus (*ENR* April 5, 1945, vol. p. 455) is an instructive summary of the developments in this field. A related type of construction to those discussed in the article is the combination of the reinforced concrete girder with a system of steel tension members that are not embedded in the concrete and remain adjustable during the life of the structure. These steel members facilitate the utilization of the dead load of the structure in creating self-sustaining artificial forces which result in an advantageous stress condition of the concrete girder.

This system is of interest in bridge design. It is applicable for the construction of any type of girder or self-anchored suspension bridge. In fact the fundamental concept of this prestressed system is analogous to the self-anchored structure principle.

In deck girder construction the tension steel reinforcing chord is arranged in the space between the ribs and after the concrete has hardened it is prestressed so as to produce axial compressive stresses in the girder of a magnitude that is sufficient to overcome the tension stresses in the concrete. The steel chord is anchored at its ends. The bars, however, are pro-

ided with screw ends and nuts by eans of which the stress in the bars n be adjusted at any time to com- ensate for the effects of shrinkage nd plastic flow. Besides adjustability, e external location of highly stressed rge steel areas has the advantage of liminating the danger of cracks that xist in embedded construction and imit the allowable steel stresses.

A highway bridge, built in Aue, Germany, in 1936 is shown in Fig. 1. The girder is 391.72 ft. long, having center span of 226.38 ft., which is ot continuous in this case. The uspended portion is 103.35 ft. long.

Tension bars anchored to floor

The tension chord of the suspended pan consists of thirty 2¾-in. dia. ound bars, ten between two ribs. These bars are anchored to the floor lab which is made thicker at the ends f the span for this purpose. From he anchorage at one end the bars re carried in groups of five under he floorbeams to the anchorage at he other end of the suspended span. Prestressing is accomplished by pull- ng the bars down at the floorbeams, he bottom of which are provided with earing plates to accommodate rock- rs. After the desired stress is intro- luced in the bars, rockers of suitable epth are inserted between the bear- ng plates at the bottom of the floor- eams and the saddles on the bars at hese locations. By the attachment of his chord, the simple beam becomes internally one time statically indeter- minate.

The tension chord of the anchor and cantilever arms consists of 36 2¾-in. dia. bars, which extend from end to end, and of twelve 2¾-in. dia. bars, which extend from the interior support to points under the first floor- beams right and left from this support, making this section of the bridge in- ternally two times statically inde- terminate. The principle of arranging the tension chord is indicated by this example.

The main bars should form a con- tinuous line from end to end of the girder, following approximately the dead load moment diagram. In the case of a three span continuous girder in which the length of the spans does not differ greatly, this line would con- sist of three parabolic and two hori- zontal sections. The latter are over the interior supports, where, as a rule, secondary chords, arranged similarly to those shown on Fig. 1, are required. The three span girder thus becomes internally a three times statically in- determinate structure. This type of combination of concrete girder with an independent steel chord is suitable for the construction of long-span re- inforced concrete girder bridges. The girder can also be built of precast sec- tions, the connection detail is simple in this case because the principal stress in the girder is always com- pression.

A self-anchored suspension bridge is shown in Fig. 2. This structure was proposed for a crossing over the harbor of Rouen, at Tancarville in France, in 1940. The bridge is 3,100 ft. long, having a 2,000 ft. center span. The suspended structure is composed of precast box sections, 100 ft. long, about 6.5 ft. wide and 11.25 ft. and 9.83 ft. deep at the sidewalks and roadway respectively. Each 100-ft. section of the suspended structure is connected by adjustable diagonal members to the towers. The horizontal components of the diagonal stresses keep the suspended structure under axial compression. This bridge can be erected without falsework by bal- anced cantilever method.

The erection method indicated by the foregoing example can advantage- ously be utilized for the construction of three-span or multiple-span self- anchored suspension bridges with precast reinforced concrete suspended structures. The towers may also be of precast sections. For the erection of such bridges, in the 200- to 300-ft. span range, a few temporary diagonal members at each side of the towers are sufficient. After the suspended structure is in place and the final parabolic cables are erected, the load can be transferred from the diagonals to them. Such bridges can be built using diagonals only or a combina- tion of diagonal and parabolic cables.

LOUIS BALOG
Consulting Engineer
New York, N. Y.

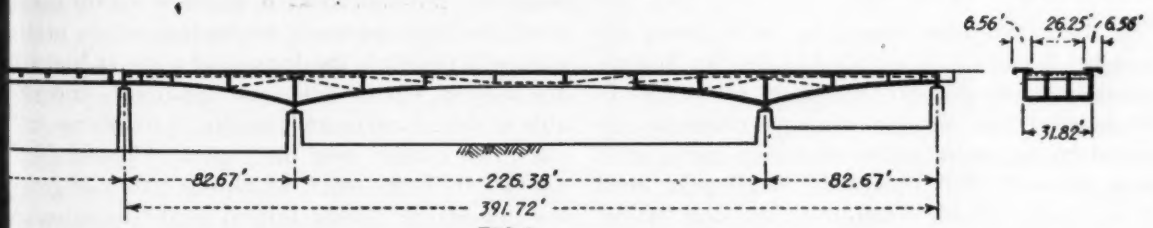


FIG. 1

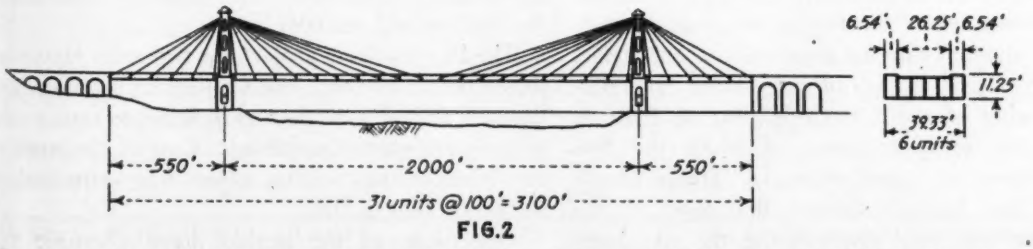


FIG. 2

The reinforced concrete girder bridge in Fig. 1, built in Aue, Germany, in 1936 has an adjustable steel tension chord, which was not embedded in the concrete and yet was used to prestress the girders. Another example of prestressing is the self-anchored suspension bridge, Fig. 2, proposed for a crossing over Rouen harbor, France. It was to have a precast reinforced concrete suspended structure.

EDITORIALS

VOLUME 135 NUMBER 16

October 18, 1945

Adequate Engineering Fees

COMMENDATION is due the Pennsylvania Department of Health for having had written into the law setting up its plan for state aid for pollution-relief planning (*ENR*, Oct. 4, 1945 vol. p. 471) a requirement that engineers engaged for that work must be paid according to the schedule of fees and salaries recently approved by the Pennsylvania Society of Professional Engineers. Engineers are finding it increasingly difficult to get adequate fees for public work, due in large part to the penurious attitude of the federal government toward fees for consulting engineers. And when a consultant gets an inadequate fee, its inadequacy generally is reflected in low pay for his employees. Neither fees nor pay need be substandard on the pollution studies in Pennsylvania, due, primarily, to the initiative of the Pennsylvania Society of Professional Engineers, but also to the Department of Health for having made adequate payments mandatory on its work. Engineers over the nation would do well to see that the precedent set by Pennsylvania is widely followed on other types of public work.

Urban Highway Needs

NEW THINKING with respect to the highway approaches to cities is exemplified by the San Antonio report summarized in our Oct. 4 issue vol. p. 430. In the decade before the war, principal emphasis was placed on by-passing cities when new routes were being planned. But Thomas H. MacDonald, head of the Public Roads Administration, kept saying that long-distance travel was only a small fraction of our total traffic, and that our major problem was that of giving better service to the short-distance travelers, who make up the great bulk of our traffic, especially around centers of population. His persistent sowing of these seeds is bearing fruit in many of the postwar plans, of which the San Antonio report is a good example. Traffic counts made at San Antonio showed that most of the vehicles on highways approaching the city were there because they wanted to get into the heart of the city, not past it. As a result, it is now proposed to run North-South and East-West highways right through the central part of the city. They are to be limited-access routes with ample interchange points close to the business district, thus providing a large measure of relief for traffic moving into and out of the city. And at the same time, traffic passing the city can move through it with no more delay than on a by-pass route. The cost of these through routes will be much higher than the cost of a by-pass route, but the investment will pay a much greater return in service to the motorist and relief for local traffic.

Another Look At the St. Lawrence

PRESIDENT TRUMAN has asked Congress for speedy ratification of the agreement with Canada for development of the international section of the St. Lawrence River for power and navigation, which was signed in 1941, but never consummated. As Congress appears to be in a receptive mood there is good reason to suppose that the agreement will be brought up for study in the near future. And as the pros and cons will then fly thick and fast, now may be an appropriate time to look at the whole project objectively.

At the outset it should be said that the reasons for undertaking the work in the not too distant future appear to be more cogent than those against its construction. But that consideration should not be permitted to obscure the fact that the 1941 agreement is far from being an ideal one under which to start the project. It requires this country to supply all the funds except for power machinery, and it leaves to an international commission the determination of how costs are to be apportioned between the two countries; it specifies a ship canal depth that now appears to be inadequate; its provisions with respect to the division of water at Niagara are unclear, out of date, and apparently inequitable to this country; and, finally, it makes no provision for control over the export of power from one country to the other, which is a matter of growing importance closely related to the question of water use. Hence, a thorough revision of the 1941 agreement is indicated, and properly approached the task should not take long.

The St. Lawrence project has two main elements: development of about two million horsepower, and construction of a modern ship canal to replace the present antiquated waterway. Cost of the work in the international section alone was estimated at $266,000,000 in 1941.

Opponents of the project have claimed, and probably will still claim, that we do not need the power. Experience with other big power projects, however, belies such gloomy predictions.

Completion of *plans* for the project, therefore, should be pushed while revision of the 1941 agreement is under way.

A channel depth of 27 ft. for the ship canal was called for in the 1941 agreement. That specification needs restudy in the light of the fact that nearly all the cargo ships we built during the war have salt-water drafts in excess of 27 ft. If we are to build a new ship channel to the Great Lakes, logic would indicate that it should be designed to pass our most modern cargo ships under full load.

Proponents of the seaway make much of the part it could play in expanding our foreign trade by opening up the Lake ports to the world's ship lanes and effecting great savings in shipping costs. Their optimism is open to question, but granted it should be justified, then those who use the seaway should be required to pay tolls at least sufficient to return the cost of operation and maintenance.

Another point worth noting is that negotiations of a new agreement with New York State might well be undertaken while the agreement with Canada is being reconsidered. Governor Dewey recently reasserted New York's claim to the power to be developed on this side of the international boundary, and President Truman has expressed approval of a plan drawn up in 1933 under which New York would acquire the power plants on repayment of the cost. Whether Congress will accept that plan is not clear; much depends on the influence of people in Washington who would like to see federal control over power extended widely across the country. Control of the power by the Power Authority of New York State, however, appears to be more logical than for the federal government to set up its own organization as it did at Bonneville.

In summary, this country can afford to build the St. Lawrence ship canal even though it may never be entirely self liquidating; and it can use the cheap power that the river will provide. There is, however, no need to rush into the undertaking without adequate advance preparation. That preparation should include revision of the 1941 agreement with Canada, and restudy of the designs made by the Army Engineers, preferably by a board of consultants chosen from the engineers of both countries. Cost estimates should be prepared thereafter, and the board should recommend a definite allocation of those costs between the two countries, which was not included in the 1941 agreement.

When these things have been done, Congress will be in a better position than it is today to determine when active construction should start. Since, however, neither the St. Lawrence power nor the deeper waterway are vitally needed at present, the project should not be permitted to compete for labor and materials with work of greater urgency, but it is proper and necessary that plans and preparations be completed now for its eventual undertaking.

From War to Peacetime Building

A YEAR FROM NOW, or perhaps sooner, building construction—factories, apartments, commercial structures, houses, and probably some city halls and postoffices—will be humming in every community of this rundown country of ours. What remains of the lessons and developments of our war building activities that will aid in this task? A special section of this issue is devoted to presenting as much of an answer to this tremendously important question as thirty-six pages will permit. Not as spectacular as some of the dreams of electronic houses and plastic offices, the facts concerning new knowledge for peacetime building are nevertheless arrest- and substantial.

As would be expected, the results of war building activities are more evident in the impetus given to development of knowledge in established fields than in completely new concepts and products. Because of the huge increase in aluminum production and use, design practices naturally received much study, with consequent simplification. Welding fabrication and design techniques benefited from the ship and drydock building programs. Shortages of steel provided a stimulus for timber and concrete structures, which were extended into a realm of new dimensions and forms. The demand for pressed steel members for military buildings prompted the manufacturers to develop rationalized design specifications for what previously had been a specialty product. Finally, one of the most significant bequests from the war was the impetus given to standardization of building product dimensions through the growing acceptance of so-called modular design principles.

Details of all these developments, given in the authoritative articles in the special building section of this issue, comprise knowledge that will make the transition from war to peacetime building easier, speedier and more efficient.

ENGINEERING NEWS-RECORD
Copyright, 1945, by McGraw-Hill Publishing Company, Inc.
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Chicago: H. W. RICHARDSON, J. R. CARR. *Washington:* A. N. CARTER. *San Francisco:* N. A. BOWERS.
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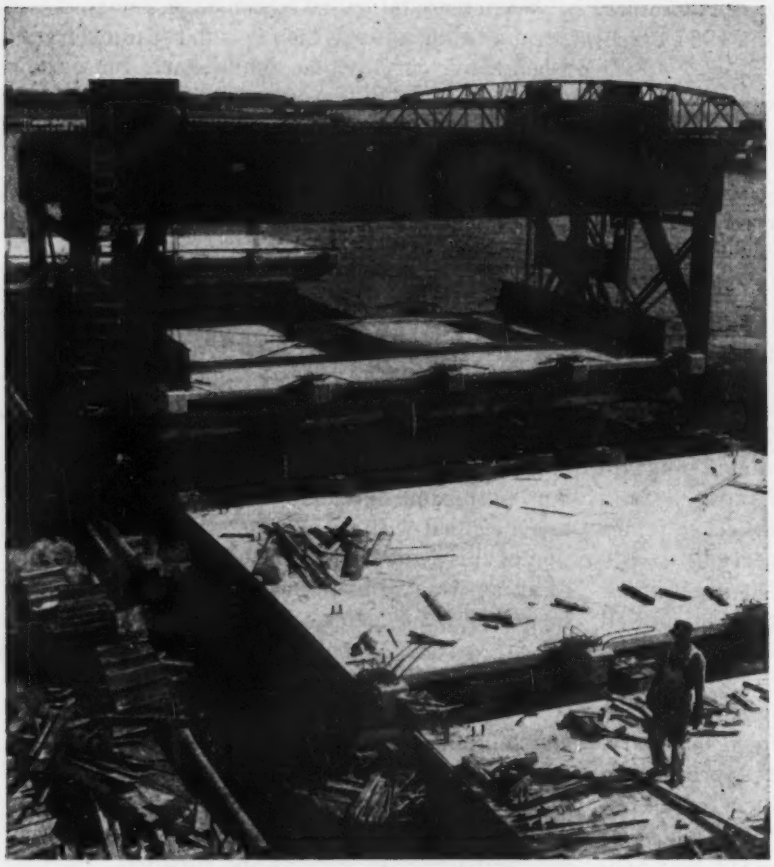


Fig. 1. The deck for a Virginia highway bridge is precast at a central yard in 40-ft. long sections, which are loaded onto barges by a gantry crane.

Deck Bridge Built Of Precast T-Beam Units

***Contents in Brief**—The deck of a long reinforced-concrete slab-and-girder bridge supported on concrete pile bents is being precast in 40-ft. lengths at a central yard. The 110-ton sections are loaded by gantry crane onto a steel barge and floated to the desired location, where water is pumped into the scow to lower the slab into place. To save form lumber and labor, previously poured piles were used as side forms for the bents.*

TO REDUCE FORM LUMBER requirements to a minimum, eliminate the need for extensive falsework, and permit concrete to be placed on a production line basis, the T-beam slab of a reinforced-concrete deck bridge under construction at West Point, Va., is being built of precast one-span sections delivered by barge. Although new to highway work in Virginia, this procedure is also expected to result in earlier completion than if the superstructure had been built by normal methods.

Totalling 1,572 ft. in length and providing a 26-ft. clear roadway, the bridge will replace an old timber crossing over the Mattaponi River on State Route 33. A 250-ft. through steel truss swing span at the navigation channel is being constructed in open position by the normal practice of utilizing the fender system as falsework. The remainder of the structure consists of thirty-three 40-ft. trestle spans supported on 5-pile concrete bents. War conditions dictated that these spans be built of reinforced-concrete, rather than with steel I-beams supporting a concrete deck, which would have reduced the cost and simplified falsework construction. The design chosen calls for a 7½-in. thick slab carried on five lines of beams with the outer members measuring 14x33 in. and the others 16x33 in.

Sufficient water depth is available at the site to permit the deck sections to be delivered by barge and lowered in place by pumping water into the scow. This latter condition, in combination with the large number of similar spans required and the several accompanying advantages previously mentioned, resulted in the decision on the part of the contractor to precast the piles and deck sections at a central yard.

Space to build six sections

The casting yard is near the bridge site at a point where materials can be delivered readily by truck and the precast piles and deck panels easily loaded onto barges (Fig. 1). Sufficient space is available to permit forms for six sections to be erected side by side in a row perpendicular to the shoreline, the roadway centerlines of the forms being placed parallel. Constructed of plywood, the forms are supported on heavy falsework timbers resting on concrete sills.

Although the east end of the bridge is on an 0.8-percent grade and a vertical curve 400 ft. long is used at each end of the swing span, the 33 reinforced-concrete spans are sufficiently similar to permit reuse of the form panels. In this work no attempt is made to lift a slab out of the forms without dismantling them, as the beams are not tapered in cross section. But the work of stripping the forms from a completed slab takes only a few hours by a small crew, and all the panels are available at the point where they must be assembled for the next pour.

Precasting the section also avoids the need for extensive work from scaffolding over open water and eliminates all falsework at the erection

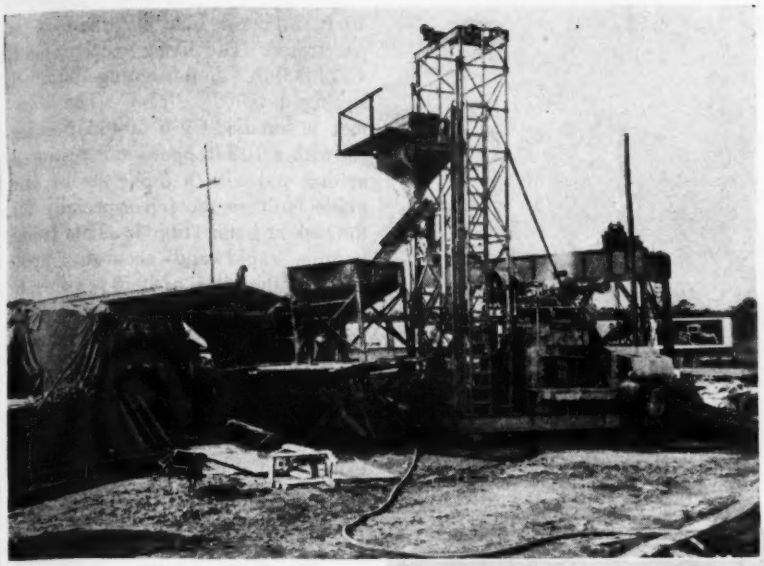
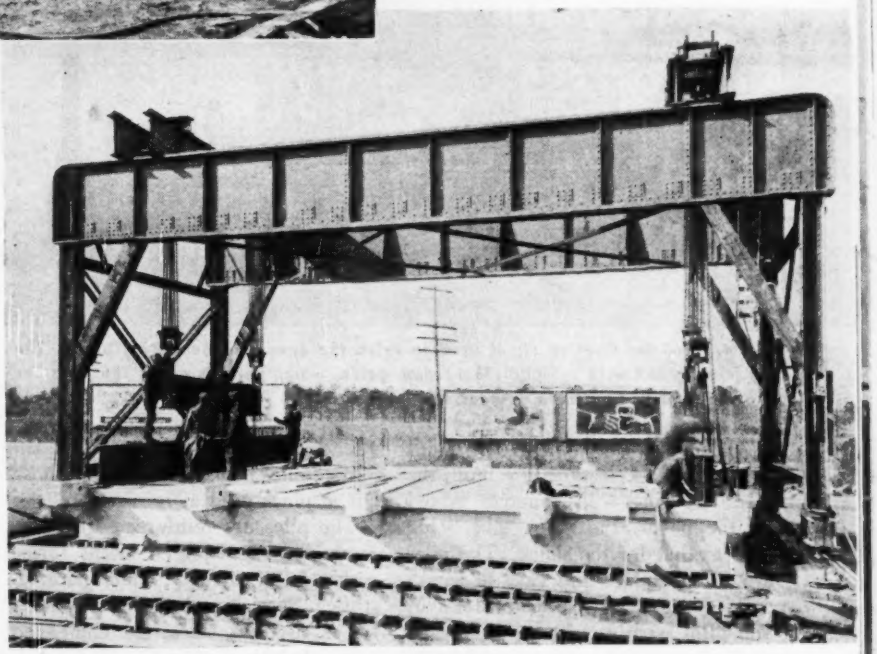


Fig. 2. By precasting deck sections (at left) on land, not only is the formwork simplified but in cold weather, when work over open water would have been difficult, concrete is readily placed inside canvas enclosures.

Fig. 3. Four hand-operated chain hoists (below) are used to suspend a completed deck section from the gantry crane. The hoists are connected through equalizing arms to two heavy I-beams attached to the slab by means of 1-in. dia. bolts with the greater part of their length embedded in the slab.



site. The latter saving is of major importance. In addition, last winter when low temperatures would have made concrete placing over open water difficult and protection of the freshly placed concrete a severe problem, tarpaulin enclosures were quickly prepared at little cost to permit operations to continue at the yard.

Steel assembly simplified

Work of assembling the reinforcing steel in the forms is also simplified, as this is accomplished on land without the aid of lifting equipment. Moreover, no extra reinforcing is added because the completed deck section will be loaded onto the scow by a gantry crane straddling the section. However, it is necessary to embed five pairs of 1-in. dia. bolts in each end of the slab to permit the section to be raised. Welded to the reinforcing steel for the beams, the bolts are properly spaced by use of wood templates. They are set in shallow wells to permit them to be burned off below roadway level when the slab is in final position, the wells then being filled with grout.

A little extra work is also required to install the necessary bearing plates in the forms. An 8x¾x16-in. steel plate is laid flat on the bottom near each end of the beam forms to match 3-in. deep recesses in the caps of the pile bents. In each plate four holes are provided, two ½-in. dia. holes 6 in. apart on the short axis of the plate and two of 1⅛-in. dia. 7 in. apart on the longitudinal axis. A ¼-in. dia. bolt about 3 in. long extending downward through holes in the forms is inserted in each small opening in the plate. These bolts permit other bearing plates to be added after the completed slab has been raised off the sills.

The larger openings in the plates are to accommodate ¾-in. dia. dowels to be inserted later in holes in the pile caps and to extend upward into the precast beams. Before the concrete is placed in the forms a 1-in. dia. pasteboard cylinder sufficiently long to extend above the forms is centered over the larger holes. This arrangement results in two holes at each end of the girders to permit addition of the dowels from above, once the slab has been transferred to the construction site and aligned over the supporting bents.

Concrete for casting the deck panels is mixed in a 27E single-drum paver. Designed for a minimum compressive strength of 3,000 psi., the mix is used as follows: Sand, 1,263 lb.; gravel, 1,833 lb.; cement, 6¼ bags of high early strength, and water, 6 gal. per sack of cement. The paver delivers the concrete to a skip hoist near the middle of the row of forms, which discharges it into a hopper for delivery to the forms by rubber-tired buggies. Vibrated in place, the concrete is finished with a longitudinal screed and it is hand-floated. The slab is kept covered with wet burlap for seven days.

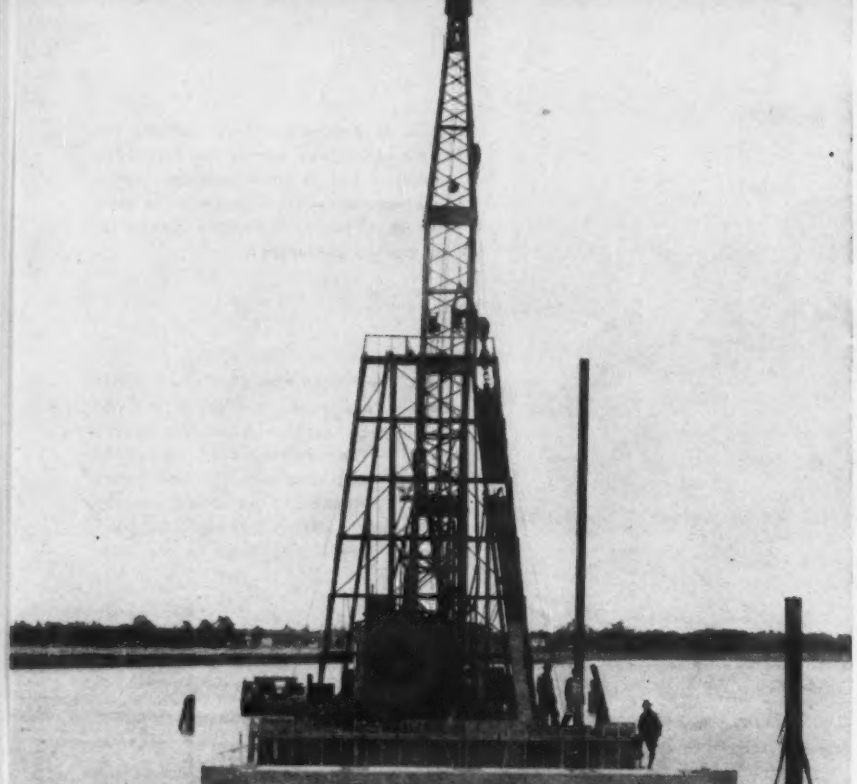


Fig. 4. A 60-ton floating rig is used to drive the concrete foundation piles. The rig is equipped with a 5-pile steel-frame guide, which permits all of the piles for a given bent to be driven without shifting the rig.

A short distance from the point where the deck sections are built, the piles are cast with concrete mixed by the paver, the same mix being used as that for the slabs. The piles are 21 in. square and vary in length from 65 to 82 ft. Since a total of 185 piles were required, much study was given to the most satisfactory method of doing this work. The plan decided upon was to construct a 4-in. thick reinforced-concrete slab 90 ft. long and sufficiently wide to accommodate about 25 piles laid side by side. In finishing the pavement, 2x4's were embedded flush with the upper surface of the slab on about 6-ft. centers to provide nailers for supporting the forms.

Alternate piles, with a 21-in. space between them, were cast in the first operation, wooden side forms being used for this work only. After the concrete had hardened, the wood forms were removed, heavy paper placed along the sides of the piles, and additional units cast in the intervening spaces. For the remainder of the piles no forms were used, alternate piles being removed and those left in place used as forms.

The piles are reinforced with preassembled cages placed in the forms with a 5-ton capacity, hand-operated, stiffleg derrick. A 60-ton floating rig is used to stack the completed piles. In this work a 4-point hitch is employed because of the long length of the members. To permit the hitches to be made readily, threaded inserts or cinch anchors about 6 in. long are embedded in the pile with the open end flush with the top surface of the concrete. The end of the anchors are sealed temporarily with wooden plugs, and when it is desired to lift the pile, the plugs are replaced with 1-in. steel eyes screwed into place.

Pile drilvng creates problem

Only major problem encountered at the construction site to date in using the precast piles and deck slabs has been in driving the piles at the west end of the project, where about 40 ft. of dense blue clay had to be penetrated. The piles are driven with a 14,000-lb. double-acting hammer having a 5,000-lb. ram. The hammer is handled by a 60-ton floating rig with a 105-ft. boom and equipped at one end with a 5-pile steel-frame guide built on the job especially for the task at hand (Fig. 4). This frame permits rapid and accurate "spotting" of the piles, as it is possible to put down the five piles for a bent without shifting the rig.

Driving of the piles is aided by jetting. For this work a 4-in. dia. pipe ending in a 1-in. dia. point is used; openings varying in diameter from $\frac{1}{2}$ to $1\frac{1}{2}$ in. were tried and the larger proved most effective. One 65-hp. centrifugal pump delivering water at a pressure of about 150 psi. permits effective jetting in coarse sand, which is the predominate soil encountered. In contrast, in driving through the heavy clay, two 65-hp. centrifugal pumps and two 90-hp. units connected in series were used. Although these pumps delivered 1,000 gpm. at a pressure of 250 psi., the progress of driving was extremely slow. The most satisfactory procedure was to do the jetting and driving simultaneously.

Construction of the caps for the pile bents follows closely behind the driving operations. Concrete mixed by the paver previously mentioned and delivered in hoppers on small barges is used, the concrete being placed in the forms by a 1-yd. bucket handled by a floating rig. In finishing the top surface of the caps 3-in. deep recesses are provided for the bearing plates attached to each end of the precast beams. Also two 3-in. wells extending about 12 in. below the cap are added at each recess (Fig. 6). These wells are spaced to match the holes through each end of the beams and they permit installation of $\frac{3}{4}$-in. dia. anchor dowels in a manner to be described later.

Setting of the precast sections on the caps has created no special problems to date. A completed section measures $27\frac{1}{2}$ by 40 ft. overall and weighs 110 tons. It is loaded on a steel barge by the gantry crane, which operates on rails extending over the water on piles forming the barge slip. The load is lifted by four hand-operated chain hoists joined to two equalizing arms in turn connected to two heavy I-beams attached to the

slab by means of the 1-in. dia. bolts embedded in the slab for most of their length (Fig. 3).

As soon as a slab has been raised above the point where it was cast, the concrete to be exposed to general view is "rubbed." This is a much easier operation at the casting yard than if done at the construction site by workmen on scaffolds. Also, to each bearing plate already attached to the beams are added a $3\frac{1}{2}$x$\frac{3}{8}$x16-in. plate and finally a 8x$\frac{3}{4}$x16-in. plate. These latter plates, which make a total plate thickness of nearly 2 in. at each end of the beams, are held in place by the $\frac{1}{4}$-in. dia. bolts previously mentioned.

Power to shift the crane with its load to the barge slip is supplied by lines from a tractor winch. When lowered onto the barge, the slab is placed on timber cribbing of sufficient height to permit the panel to clear the pile bents when the scow has been towed to the desired point (Fig. 5).

Transfer of slab to piers

Transfer of the load from the barge to the piers is a simple operation. By means of turnbuckles in chains tied between the last slab placed and that on the scow, the panel is first carefully aligned in the horizontal plane and the dowel holes through the slab made to match those in the pier caps. After the dowels, which are $\frac{1}{4}$-in. dia. rods about 3 ft. long, have been inserted the slab is lowered onto timber cribbing on the pile bents by pumping water into the barge. The scow, now floating free, is then removed.

Next the load is transferred to four 25-ton screw jacks installed under each end of the slab. After the recesses in the pier caps have been filled with a 1:1 cement mortar, the load is lowered into final position, the jacks supporting the slab at the final elevation until the mortar remaining in the recesses has hardened. At the same time the dowels are secured in place by filling the remaining space in the holes with mortar. This method is resulting in accurate grade and alignment throughout the length of the bridge.

The only work remaining, once the jacks have been removed, consists of burning off the tops of the lifting bolts, filling the wells with mortar, and constructing the hand railing and the 18-in. wide safety walks. In this latter work a 3-in. high opening continuous between the handrail posts is provided at deck level. These openings will not only permit much more rapid runoff of rain falling on the deck, but they will result in the roadway being kept free of snow and dirt by wind action.

The contractor's organization points out that the methods described are considered highly successful, but if the procedure were to be used again the safety walk and railings would probably be precast. Work already completed indicates that this could be done satisfactorily and that it would simplify operations in the field.

An operation feature of the bridge when travel must be halted and the swing span opened will be the use of two sets of safety gates on each side of this span. The barriers of each set will be spaced 160 ft. apart. It is felt that a driver unable to halt for the first guard can bring his vehicle to a stop before reaching the second, which will be located 40 ft. from the swing span.

The $400,000 project is being carried out without federal aid by the Virginia Department of Highways, C. S. Mullen, chief engineer; W. R. Glidden, bridge engineer; and H. E. Piercy, resident engineer.

Diamond Construction Co., Washington, D. C., is the general contractor. For this firm Burt Crumrine is superintendent.

Fig. 5. The precast deck sections are transferred to the construction site by barge, being supported on timber cribbing of sufficient height to permit the load to clear the completed pile bents. By pumping water into the scow, the slab is easily lowered onto the substructure.

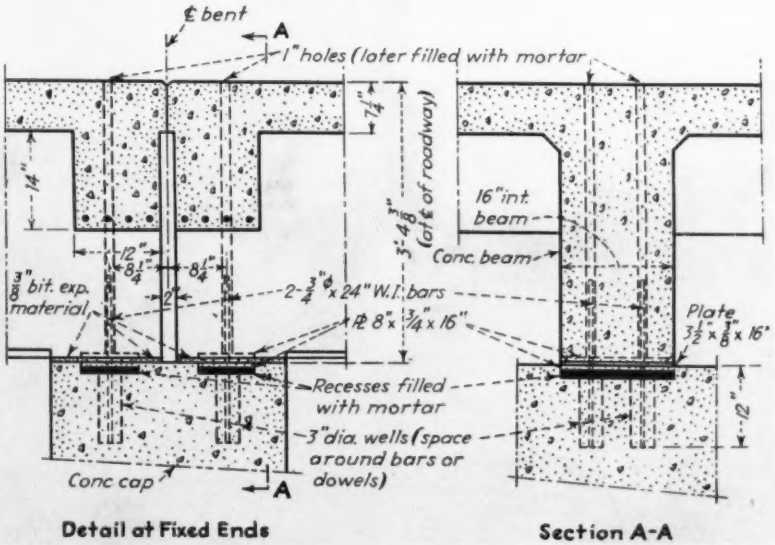


Fig. 6. In setting a slab in place, the recesses in the bent caps for the bearing plates attached to the slab are filled with mortar. Then the section is lowered to correct position and the load supported on jacks until the mortar has hardened.

Fabric Cells Used for Underwater Salvage

***Contents in Brief**—U. S. Navy aircraft, including the heaviest planes, are raised and salvaged from water depths within the range at which divers may work effectively by the use of large fabric cells. After the cells are attached to the load they are inflated by small portable compressors, the spheres being equipped with flutter valves that "bleed" automatically to prevent excessive pressure inside the cells as they rise. The divers wear suits of a new design weighing about 50 lb. less than the naval standard.*

A COLLAPSIBLE rubberized fabric cell developed by U. S. Navy engineers for underwater salvage work is a new war tool which may find valuable applications in the construction field. An improved light-weight suit worn by the divers attaching the cells to the object being raised offers possibilities of even wider use by the construction industry.

Both items are the outcome of over two years of experimental and research work to salvage aircraft and other large pieces of war equipment sunken in deep waters. The results were so successful that a PB2Y-3 seaplane, one of the Navy's heaviest aircraft, was recently raised from a depth of about 100 ft.

Two sizes of salvage cells are used, a 58-in. dia. sphere weighing only 40 lb., with a positive buoyancy of 6,000 lb., and one of 84-in. dia. weighing 75 lb. with a buoyancy of 12,000 lb. Thus, a small number of cells will provide considerable lifting capacity. Both sizes are made of a rubber-impregnated laminated material that is water repellent, airproof, and capable of withstanding high hydrostatic pressures.

The cells are lowered over the side of the small craft used by the salvage crew in a deflated condition. They are then attached by the divers to the craft to be raised. An accompanying photograph shows several shroud lines glued to one of the smaller balloons, which was the first method used to attach the sphere to the sunken object. An improved design has been developed for the 84-in. cells. This method consists of enclosing the spheres in an open-mesh, flexible, wire guard that protects the fabric from puncture or damage and provides additional strength against rupture.

Cells have pressure relief valves

Both sizes are designed for operation with a pressure differential of 3 psi. Since the hydrostatic force on the sphere reduces rapidly as it rises, the problem arose as to the best method of "bleeding" the cell as it traveled upward. With the smaller spheres this problems was solved by the use of a diaphragm valve located in the top of the cells, the valve keeping the pressure differential within 2.5 psi. of that desired. Later a flutter type valve was designed and incorporated in the 84-in. dia. cell. This design has proven so satisfactory that it will be used in all future cells. The action of the flutter valve is so positive that it will "bleed" sufficiently fast to prevent rupture of

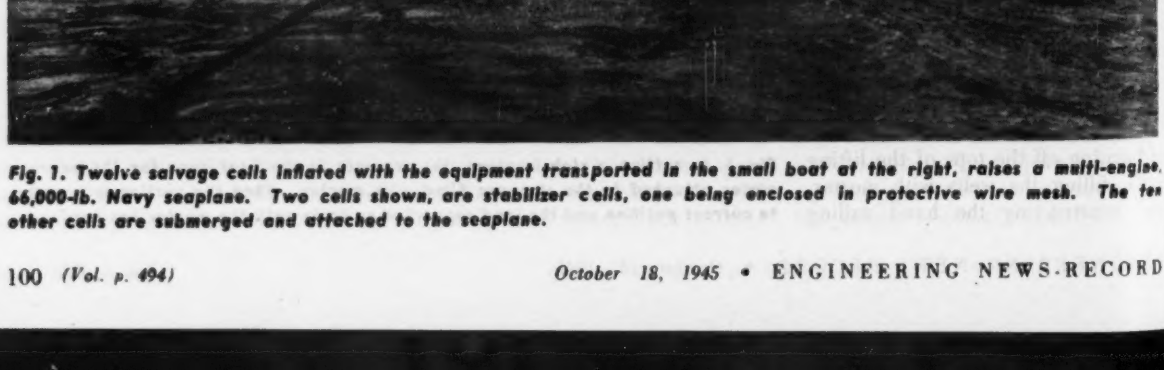


Fig. 1. Twelve salvage cells inflated with the equipment transported in the small boat at the right, raises a multi-engine, 66,000-lb. Navy seaplane. Two cells shown, are stabilizer cells, one being enclosed in protective wire mesh. The ten other cells are submerged and attached to the seaplane.

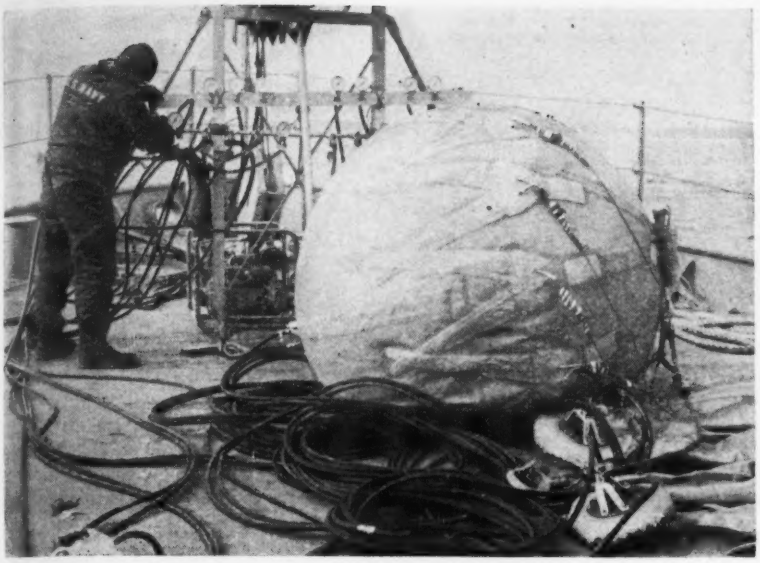


Fig. 2. Supplied by a compressor easily transported manually, air required to inflate cells is delivered to a manifold permitting flexible control of supply to each cell. Shrouds attached to inflated sphere, which will be collapsed before being placed in water, provide means of attaching cell to load. Large cells (not shown) are equipped with flexible wire cable shrouds joined to steel plate at top of cell.

a cell rising at a rapid rate or with only a comparatively light weight attached.

In the early stages of the work a 30-cfm. compressor weighing several hundred pounds was used to inflate the cells, but to make all of the salvage equipment small enough to be handled conveniently by the salvage crew this unit has been replaced by a 12-cfm. compressor weighing only 250 lb. Air from this unit or series of these compressors is delivered to a manifold and from this point to the various cells through individual lines. Air gages are used to accurately control the amount of air being pumped to any given sphere.

Once inflation of the cells is begun, only a few minutes are required to raise the load. Moreover, because of this accurate air control system it is possible to keep the load on an even keel, which is important in many salvage operations.

Diver's suit of light weight

The divers attaching the cells to the load wear light-weight suits offering a number of advantages. They are made of rubberized canvas and the large heavy helmet so common to the older type suit is replaced by a plastic mask, which was an important factor in reducing the weight of the new suit to less than 20 lb. The low weight of the suit permits the diver to move about under water much more freely than was possible with the older type suit. As a result, the diver is able to do many more operations than divers in the past and less energy is required to move about, which is expected to permit a worker to stay submerged for longer periods than formerly.

Fig. 3. New type suit has split in back that is sealed with clamps after wearer gets inside "dress". Round metal piece over diver's head is diaphragm permitting escape of used air.

Air for the divers when submerged is delivered in the feed lines at a temperature of about 96 deg. F. It is supplied at a relatively low humidity to eliminate the possibility of condensation in the lines—an important factor on salvage work in cold weather.

New device being designed

Currently under development by Navy engineers is an attachment for the new suit which may make it still more advantageous. Known as a "de-breather", the unit is expected to be attached to the back of the suit at about the neckline. It is planned to introduce automatically oxygen into the air mixture in the suit when the air hose leading to the diver is cut or for some other reason fails to supply sufficient fresh air. The "de-breather" is being designed to remove the carbon monoxide from the entrapped supply, and, as the air is re-circulated, add oxygen. Sufficient oxygen will be available to sustain the diver for about an hour.

The salvage equipment described was developed by the aircraft maintenance branch of the Navy's Bureau of Aeronautics in cooperation with the Bureau of Ships. In the former Bureau, Capt. E. W. Clexton is head of the maintenance division and Comdr. R. E. Coombs head of the branch, while in the Bureau of Ships Capt. B. E. Manseau is head of the ship salvage branch and Lt. A. W. Mott, in charge of diving operations. Lt. Comdr. H. T. Bogle, now head of a special equipment development section in the Bureau of Aeronautics, was in charge of the research and experimental work in developing the flotation cells, and established the specifications of the light-weight suit, which was developed by the Experimental Diving Unit.

The cost of the first salvage cells was about $500 and the first suits about $100 each. Both of these costs are considered high, but it is expected that with large scale production a greatly reduced price will be possible.

Fig. 1. The breakwater at this point is unprotected from the open sea. Concrete barges at left were wrecked by a typhoon.

Building the Port Apra Breakwater

R. P. Day
Chief Carpenter's Mate, U. S. Naval Reserve

***Contents in Brief**—By June Seabees had completed about one-third of a 2,000,000-cu.yd. rock moving job on Guam to provide breakwater protection for Apra Harbor. For temporary harbor protection, concrete barges 335 ft. long were sunk in 30 ft. of water on the breakwater line, but before the rock fill reached them, storms moved them aside. Attention was then concentrated on the fill, which was composed of quarry rock rated as "coral limestone"; the latter was of such a nature that 1.5 to 2 lb. of powder per cu.yd. was required for blasting. Typhoon storms dictated the use of armor rock facing ranging up to 30 tons in weight.*

THE PORT APRA BREAKWATER, built to protect the harbor at Guam, will be a 2,000,000-cu.yd. rubble mound structure on which Seabee ingenuity has been wrestling with large-scale rock-handling problems. Speed was important when, after three years of Japanese occupation, the work was resumed without adequate equipment for handling and placing heavy rock.

As the urgency was great, concrete barges were sunk as a temporary, emergency measure in a row along the center line of an exposed portion of the proposed breakwater, where the water depth is 30 ft. These barges were to be covered by the fill to be placed later, utilizing dump truck delivery of quarry-run rock and heavy rock for armor facing.

This breakwater project was originally started in 1941 by Pacific Naval Air Base Contractors with whom the Navy made a contract for work estimated to cost $5,753,000. While preliminaries were still under way early in August, 1941, a typhoon struck Guam, bringing wind velocities as high as 125 mph. Ground swells then observed were such as to demonstrate the need of great strength and stability in the breakwater.

This is because the entrance to Port Apra has no natural protection from the open sea. Nearest shelter, such as it was, was afforded by coral shallows known as Luminao Reef, which extends about 1½ mi. toward the harbor entrance from Cabras Island, the best location for the shore end of a breakwater. This reef, which is about 3 ft. under water at low tide, broke up the swells somewhat, but during heavy storms the protection was inadequate.

Location for the breakwater was made on a somewhat curved center line whose inshore end is on Cabras Island and extends thence along Luminao Reef to take advantage of the shallow water. Beyond the end of this reef the breakwater has to continue nearly 7,000 ft. along what is known as Calalan Bank, where the depth is 30 ft. and across which ocean swells sweep unhindered.

During early discussions of design in 1941, a plan for using precast concrete blocks as armor for the sides and top of the breakwater was considered and rejected. It was decided to build the structure of quarry-run rock, armored with heavier stone. Sufficient rock could be quarried on Cabras Island, whence the haul is short. With slow velocity powder, 15 to 20 percent of the rock blasted would be in the 3- to 5-ton range.

This quarry was expected to yield 3,000 cu.yd. per 24 hr. Waste was estimated to run about 25 percent and

it was thought that bad weather would nullify 20 percent of the total working time. Duration of the job was estimated by the contractors as 450 calendar days from Mar. 1, 1942. These estimates were all made in 1941.

The PNAB contractors began work late in that year. The Cabras quarry area was cleared, a road was built out to the breakwater approach and some stone was drilled and shot. On Luminao Reef, where the breakwater section was to be 20 ft. wide and 2 to 3 ft. above mean tide, nearly a mile of the fill was placed. Some 64,000 cu.yd. of stone had been delivered when construction was halted abruptly on Dec. 8, 1941, by the arrival of Japanese troops. Captured civilians and garrison troops alike were herded into ships bound for Japanese prison camps. The Japs did nothing on the breakwater, and such American equipment as the Japs did not steal was left to rust at the site.

Three years later when we recaptured Guam in July, 1944, Seabees found the scene of the PNAB contractor's activity covered with weeds and brush. While the Luminao Reef causeway had suffered some wave damage, it was still in place. It could be traversed by a jeep, which may or may not be any proof of its serviceability, jeeps being what they are. Most of the remaining heavy equipment was ruined. The Nips had shipped some of it to Saipan and some to Japan.

Four rusty heavy trucks, given up in despair by the Nips, were made to run again by Seabee repair men. Two badly damaged shovels and one 3½-cu.yd. crane yielded a few spare parts, but for the most part the job had to begin again.

Temporary harbor protection

When the Seabees reached Guam, temporary breakwater protection had already been proven feasible off the Normandy coast. The idea seemed applicable at Apra because quite a few empty concrete barges were available. It was proposed that seventeen of these vessels, 355 ft. long, 36 ft. deep and of 54-ft. beam, be sunk along the Calalan Bank. The plan was to put them in locations where, when the fill progressed that far, they could be incorporated in the breakwater by blasting the decks open and filling the ships with quarry-run stone. In the interim between the sinking of the barges and their incorporation in the breakwater, it was hoped that they would furnish temporary protection for ships at anchor in Port Apra.

Underwater work to prepare for the sinking of the barges began on Calalan Bank in 30 ft. of water. The ocean floor was shot heavily to level any protruding coral heads. This underwater blasting was intended to give each ship a firm, even bearing on the ocean floor. The vessels were stripped of all salvageable gear, and then towed in along the breakwater axis and pumped full of water. By the first of October 1944 five such barges were placed. Another was accidentally sunk in deep water, fortunately with no loss of life.

But it seemed as if the Pacific was waiting to strike. On the 4th and 5th of October enormous ground swells caused by a typhoon swept in to Port Apra. All five of the concrete barges broke in the heavy sea. All five shifted position, some of them as much as 100 ft. When the storm was over, only the stern end of one barge still lay in the breakwater line.

The sinking of concrete barges was not resumed and attention concentrated on the breakwater as originally planned.

Drilling and blasting equipment

No standard battalion equipment is designed for work as heavy as the Port Apra breakwater. When the project was assigned to a construction battalion, it was necessary to order special loading and hauling units. Meantime, all available heavy equipment in other battalions and pools then operating on Guam was secured, but this resulted in only the

Fig. 2. Air view looking inshore along the causeway or approach section traversing Luminao Reef where water depth is only 3 to 4 ft. Cabras Island, on which the quarry is located, is in center background.

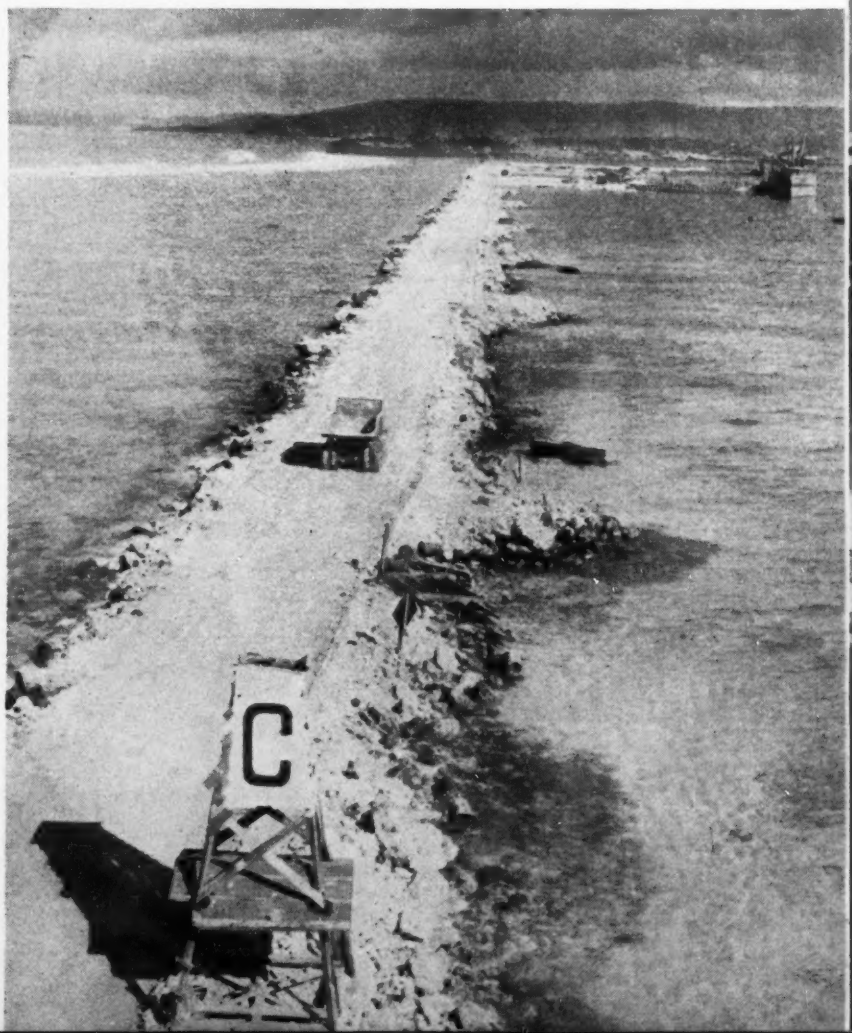


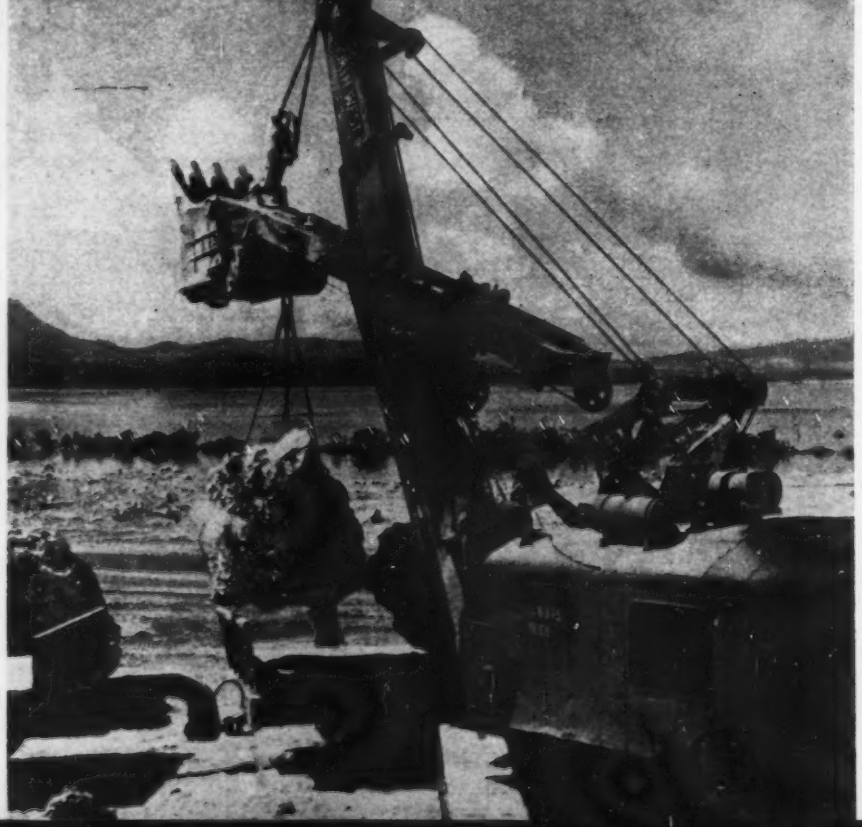
Fig. 3. Air view showing a part of the 1.1-mile quarry face from which rock was excavated for the breakwater. Stones weighing 3 to 5 tons are loaded on track-laying trailers that dump to the side.

best available substitute for what was really needed. The list accumulated included shovels, motor trucks, side dump trailers, bulldozers and the usual associated items.

But this job involved very rough ground and exceedingly heavy loads. Light units could stand up only so long and subsequently were in the repair shop—and the repairs were heavy. Moreover, some of this equipment had been "borrowed" and often had to be diverted back to other work. The 6,000 miles separating Guam from the mainland made it very difficult to get delivery of spare parts and special equipment. The real difficulty on the job was this urgent need of equipment.

On order as this was written was a list of especially heavy equipment that would greatly speed and improve the quality of the job in heavy armor placement. Included were twenty 40-ton trucks, twenty low-bed trailers with power units and three heavy locomotive cranes. Arrival of this list of needed equipment would please the hard pressed Seabees almost as much as notice of a states-side furlough.

Fig. 4. Wire rope slings attached to dipper sticks enabled each shovel to handle rock of largest size as well as quarry run material.



Cabras quarry rock is composed of limestone formed by animal and nullipore coral, which weighs 150 to 160 lb. per cu.ft., and is seamed and broken by seismic action and tree roots. Where this rock is exposed to the elements it becomes brittle and very hard. Farther in, drillers find it softer and more porous but more treacherous to drill and shoot. Seams, caves and the porosity of some of the rock absorbs the force of explosives to such an extent that 1.5 to 2 lb. of powder must be used per loose cubic yard.

"If these guys ever load blue granite that heavy when they get back to the states, I want to be in the next county!" remarked one weather-beaten drill boss.

Peculiarly enough, the rock does not dull drill bits readily, nor will it cause them to lose gage. Detachable bits used on wagon drill and jackhammer steel can be used to drill 500 to 1,000 ft. of hole before resharpening.

Wagon drills are being used on 24-ft. ledges. As these holes go down, the diameter is reduced with each 6-ft. change of steel. Thus the 2¾-in. bit used on the first 6 ft. is stepped progressively to 2½, 2¼ and 2 in. in the three succeeding lengths. Time used in sinking a 24-ft. wagon drill hole with detachable bits ranged from 1 to 3 hr., depending not upon the hardness, but upon the softness of the rock.

Where coral rock is soft and porous, many of the drillers not accustomed to it have trouble with drills sticking. The penetration rate with detachable bits can very easily exceed the proper factor of pulverization, resulting in a deposit of tailings above the bit. This sticks drill steel. As a result, rifle bar nuts on wagon drills have suffered when steel was being pulled by brute strength and awkwardness.

Coral-blasting technique

Holes, spaced on 15-ft. staggered centers, are being sprung with fifteen half-pound sticks of 60 percent gelatin, resprung with 45 sticks, and then loaded with 300 to 400 lb. of 40-percent powder per hole. Both stick and granular powder have been used. The latter works more efficiently because it fills cracks and fissures better than do the sticks. A greater weight of loose powder can be placed in a coral spring-cavity for that reason.

Beach sand stemming 19 ft. deep is tamped in on every charge. The blasts are fired by two ½-lb. sticks of 60-percent dynamite, with a No. 6 cap, set in the center of the charge. The largest blast thus far fired used 76,000 lb. of powder. Ordinary shots run from 6,000 to 20,000 lb. Due to the corrosive action of nitroglycerin salts on copper exploders, the caps are dipped in cup grease before being placed, especially if a blast requires several days to load.

The most satisfactory procedure in drilling for rock of breakwater size has been with churn drills. The machines, swinging a 1,750-lb. tool string, are averaging one 50-ft. drill hole per 16-hr. day. This includes about 8 hr. for moving, setting up and leveling the drill rig, and 8 hr. at 6 to 7 ft. an hour to sink each hole. As there is no ground moisture in the Cabras quarry, water for making drill mud must be hauled in by tank wagon.

Fig. 5. Typical quarry face from which power shovels load quarry-run material for the breakwater core.

Churn drill holes are going down on 17- and 18-ft. centers. A 50-ft. vertical face has now been well established for several hundred feet. A blast set off as this is being written brought down some 6,000 tons of rock in just the sizes desired. About 25 percent of this blast would easily exceed 10 tons in weight.

Churn drill holes are bailed dry, sprung with 50 lb. of 60-percent Herculite bag powder, resprung with 150 lb., and then each hole is loaded with 1,400 lb. of 40-percent granular powder. This amount is varied in the field, perhaps 200 lb. either way, depending on the amount of toe breakage necessary at the foot of each hole. Two Seabee powdermen recently loaded 7,000 lb. of granular powder in one 8-hr. shift. Holes are being carried about 5 ft. below quarry floor grade. Two sticks of 60-percent gelatin, with a No. 6 electric blasting cap, are also used on well drill holes.

To give an idea of the heavy blasting requirement in moving this rock, 650 lb. of powder placed in a wagon drill hole failed to break the surface of the ground. These failures are rare and happen only when the stone is unusually tough or seamed. Seabees have on occasion, when drilling into caves, bored "coyote" holes and placed obsolete military TNT demolition charges in the caves to be

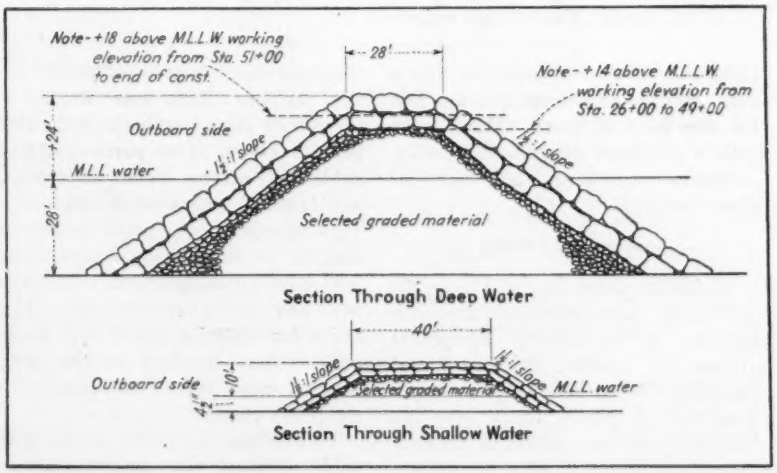


Fig. 6. Typical sections of Apra breakwater. Working elevations referred to by notes are kept below the finished level until the work nears completion, thus providing a wider road for the trucks.

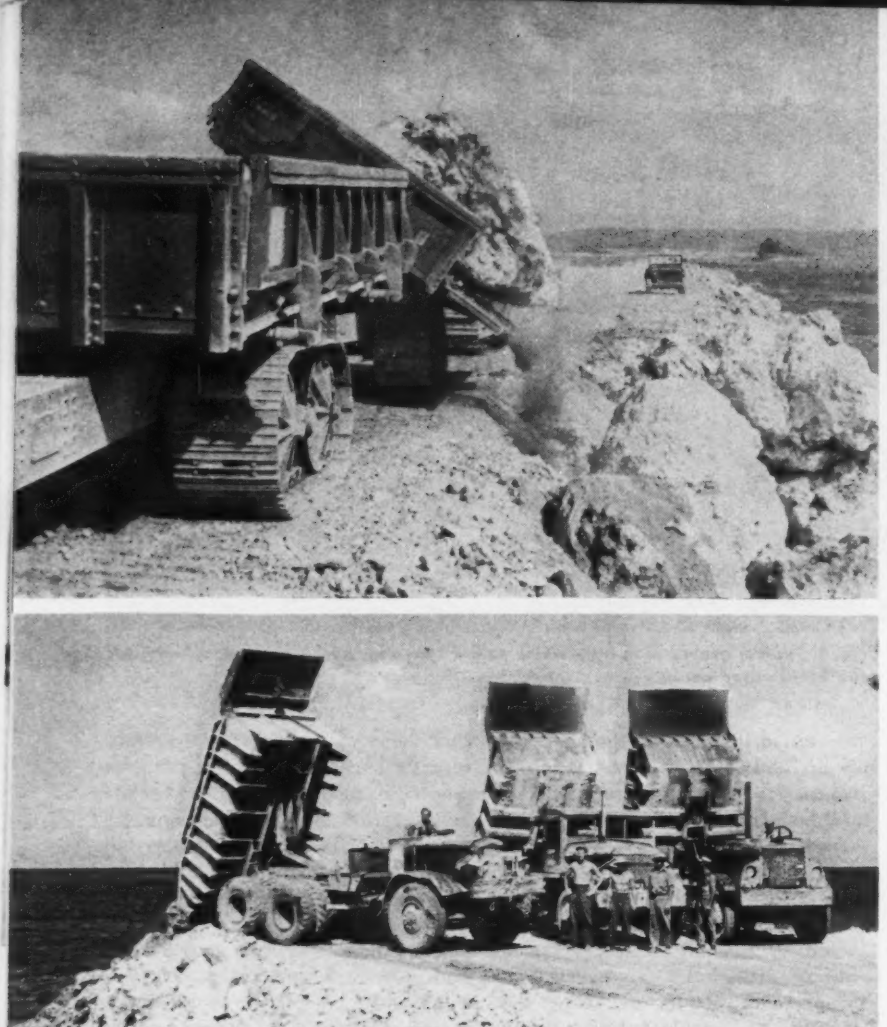


Fig. 7 Side dump equipment (at top) delivers heavy stone on the seaward face. Bulldozers supplement the dumping where necessary. Below: The fill is advanced by trucks that back up for end dumping.

fired with nearby drilled holes. As a rule, military explosives are too fast for this kind of work. More large rock is produced with slower velocity industrial explosives and conventional methods.

Loading and hauling

Handling stones in the 10- to 25-ton range has presented problems because of the heavy equipment needed for loading, delivering and dumping. When a shot brings down a section of quarry face, these big boulders are well scattered through the pile.

One of the Seabees got the idea of using cable slings on shovels to load the big stones and this has proved the most effective plan yet tried. For this purpose cleats were welded to the dipper stick just back of the dipper lip hinge. Two parts of 1¼-in. cable were strung across these cleats and fastened with several cable clips. This adaptation was made on all five shovels so that each machine can load quarry-run rock or derrick stone wherever it is encountered. This saves the excessive travel over rough quarry floor involved by the prior plan of using special equipment for the heavy pieces.

In loading the heavy stones with cable slings, it was desirable to use rope which combined flexibility with great strength and ease of application. These slings must be handled constantly and the irregular shape of most of the derrick rock caused all but the best of slings to twist and curl. Wire rope that gave the best service record is 6x37 preformed plow steel with a hemp center. Preformed rope takes the sharp bends around rock edges and still does its work.

Shovels used extensively

Shovels have been particularly effective in handling the heavy rock because after a big stone is loaded it can be crowded one way or another by the dipper stick, something not possible where a crane is used. If the rock comes out fairly rectangular, one of the shovels can make a load every 15 min.; 30 min. is nearer the average. The crawler tread wagons, called "hell boxes" because they make so much noise on the hard ground, go to any rock pile where derrick rock is exposed, and whatever shovel is in the vicinity loads them. Other types of trucks are also used.

Electric power is supplied from a power house erected near the job to generate power for this machine and for night lighting. Alternating current goes to a 5-yd. electric shovel at 2,300 volts and is there converted to direct current by a motor-generator set. In heavy digging, the field-improvised, Seabee-built switchboard and instrument panel shows that this shovel uses 90 amp. at 2,300 volts.

When most of their equipment is working, the Seabees have actually exceeded the contractor's estimated quarry output. An average of 3,800 cu. yd. per day has continued for a month. This figure is based on an estimated 10 cu. yd. per truckload hauled to the breakwater and checks fairly close to volumetric measurements made on the breakwater.

Delivery and dumping

In order to avoid erosion of the haul-road by wave action, Seabees found it necessary to increase the top elevation of the breakwater as the work progressed outward from the relatively shallow water of Luminata Reef to the 25- and 30-ft. depths over Calalan Bank. At present the working elevation is being carried forward at several different steps or levels. From the Cabras Island or shore end outward to Station 22 + 00 (a distance of 7,200 ft.) the present working elevation is plus 7 ft. with a haul-road width of 40 ft.; final

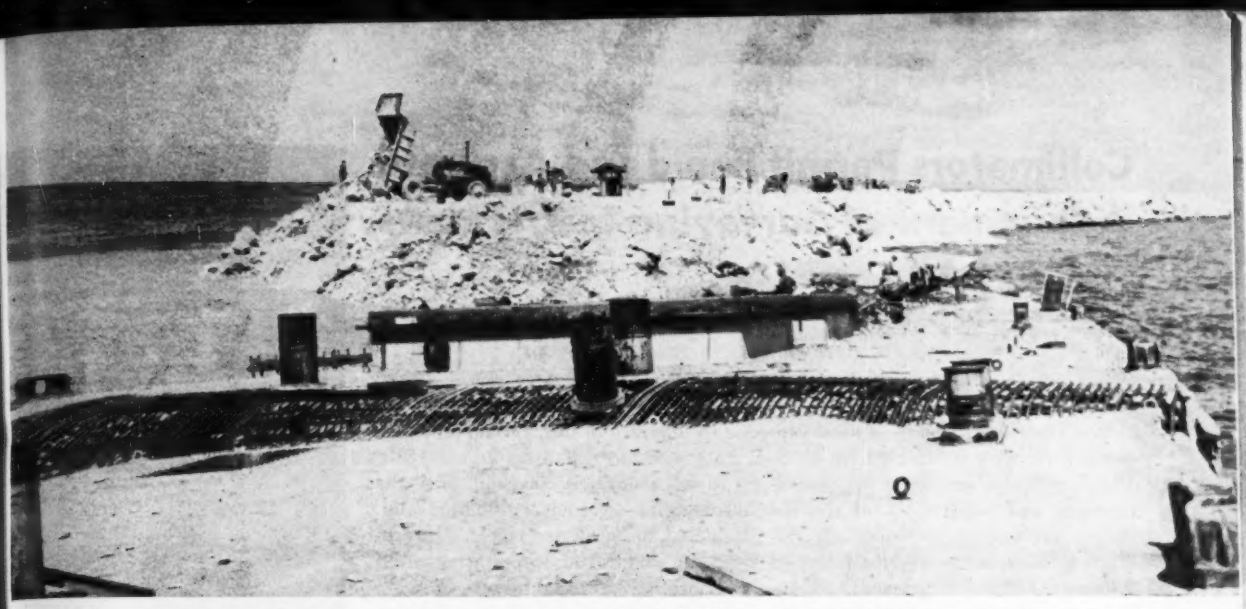


Fig. 8. This concrete barge lies in 30 ft. of water on the harbor side of the breakwater which will pass by to the left. A typhoon destroyed all the other barges which were intended to serve as a temporary breakwater.

sign elevation will be plus 10 ft. Following a short 2-percent sloped section, the second level extends from Station 26 + 00 to Station 49 + 00 (a distance of 2,300 ft.) at a working elevation of plus 14 ft. with a haul-road width of 58 ft.; final design elevation will be plus 24 ft. Following another short 2-percent sloped section, the third level extends a distance of 800 ft. from Station 51 + 00 to the outer extremity of the breakwater at Station 59 + 00 at a working elevation of plus 18 ft. and a haul-road width of 46 ft.; final design elevation, like that of the preceding section, will be plus 24 ft.

Thus, with the projection of the breakwater out into the more exposed waters of Calalan Bank, the Seabees have met the increasing wave action with corresponding increases in the elevation of the haul-road or working level. Because the water-line width of the breakwater has been maintained constant, the 1½:1 design slopes of the sides result in a reduced width of top working area with each increase in working elevation.

Second phase of construction

Actual construction is being carried forward in two stages or "phases." In the first phase, the rubble core and the 20- to 30-ton seaside armor stone are being placed, maintaining the prescribed elevations. It is considered necessary to place armor rock on the sea side immediately after the rubble core goes in in order to prevent erosion by heavy waves. The work is carried on in several stages or lifts, thus providing at lower levels greater areas for hauling, dumping, bulldozing, and truck turnaround than would be possible at the higher elevations.

Second phase of construction

In the second phase, the approach causeway and main breakwater will be at its final design elevation, the 10- to 20-ton harbor-side armor stone will be placed, and the entire breakwater will be top-armored with 20- to 30-ton cap rock. The outer end of the breakwater will be triple armored with 20- to 30-ton stone, pressure grouted if necessary.

In calm weather, working in 28 ft. of water and from an 18-ft. elevation, dumped rock yields about 1 lin. ft. of first-stage construction per twenty dumped loads. Dumping produces side slopes of about 1¼ on 1, with which comes a perplexing problem that only the arrival of a heavy crane will solve. The quarry-run toe, as dumped, falls unevenly. When derrick stone is dumped on top of that, the big stones often hang up near the toe on smaller obstructions, thus creating voids which are somewhat vulnerable to wave action until additional stone can be placed. End-dumped stone, which does not fall over the side is pushed over by a bulldozer, which cleans up behind both the dump trucks and the crawler-tread wagons.

A fast, smooth, coral highway which has been built over the breakwater, speeds up hauling. It is serviced daily by a motor grader.

The Seabees have nearly 10,000 lin. ft. of breakwater to build beyond their starting point. Completion is expected before the end of 1945. Total yardage involved is nearly two million, of which 602,000 had been placed by June 1, 1945.

As this was written, dumping and hauling was being carried forward 16 hr. a day, and drilling in the quarry was on a two-shift basis. Seabees are pushing first-stage construction so that ships and piers will have some benefit in the form of shelter before second-stage construction begins. That portion of the breakwater already in place is affording important protection to vessels and pontoon piers in Apra Outer Harbor.

Thus, despite the shortage of equipment, difficulties of supply, lack of spare parts, end dumping, hard blasting, and countless minor obstacles, the Seabees are slugging ahead doggedly and are winning this battle of men against the sea.

Those in charge

Officers handling the project include Commo. W. O. Hiltabidle, Jr., USN, officer-in-charge of Guam's naval construction brigade; Comdr. E. B. Cavallo and Lieut.-Comdr. J. S. Glunt, of the construction regiment; and Comdr. F. L. Endebrock, officer-in-charge of the naval construction battalion. Lieut. W. C. Wing and Chief Carpenter James Harris, both of this same battalion, have charge of the field work.

Collimators Permit Rapid and Accurate Adjustment of Surveying Instruments

N. B. Foster and **L. C. Higbee**
Physicist, U. S. Weather Bureau, Washington, D. C.
Engineer, W. and L. E. Gurley, Troy, New York.

The use of precision optical apparatus recently assembled by U. S. Weather Bureau engineers for the collimating and adjustment of theodolites is proving highly successful. So much so that the procedure followed is considered to offer several advantages to cities and state highway departments in adjusting surveying instruments.

The apparatus is illustrated by the accompanying photographs. It consists of two infinite-focus telescopes mounted about 12 ft. apart on rigid supports and in a horizontal position facing each other. For mounting the theodolite to be tested, a sturdy, adjustable elevation support is placed midway between the telescopes, which are referred to as horizontal collimators. A third telescope focused at infinity is supported in a vertical position directly over the theodolite stand, this instrument being rigidly supported by a pipe attached to an overhead girder.

In operation the horizontal collimators are adjusted to the same elevation, accurately leveled, and the cross-hairs in each collimator illuminated to serve as targets. Due to the fact that the telescopes are focused for parallel light, the targets function as if they were placed several miles apart, one on either horizon and 180 deg. apart with respect to the theodolite to be tested. Illuminated cross-hairs in the vertical telescope serve as a zenith target, placed at 90 deg. from the horizontal targets.

Superior to outdoor methods

This method of collimating and adjusting theodolites, which permits a theodolite to be collimated to an accuracy of about 5 seconds of arc, is superior to outdoor methods usually employed because of a number of advantages. These include: The targets are effectively at infinity, rather than at relatively short distances away; temperature effects can be controlled, since the apparatus is confined in a small room; the adjustments are not affected by light shimmer due to variations in air density, as may be the case when checks are made out-of-doors; and finally, due to the rigidity of construction and installation, no difficulty is encountered from vibration.

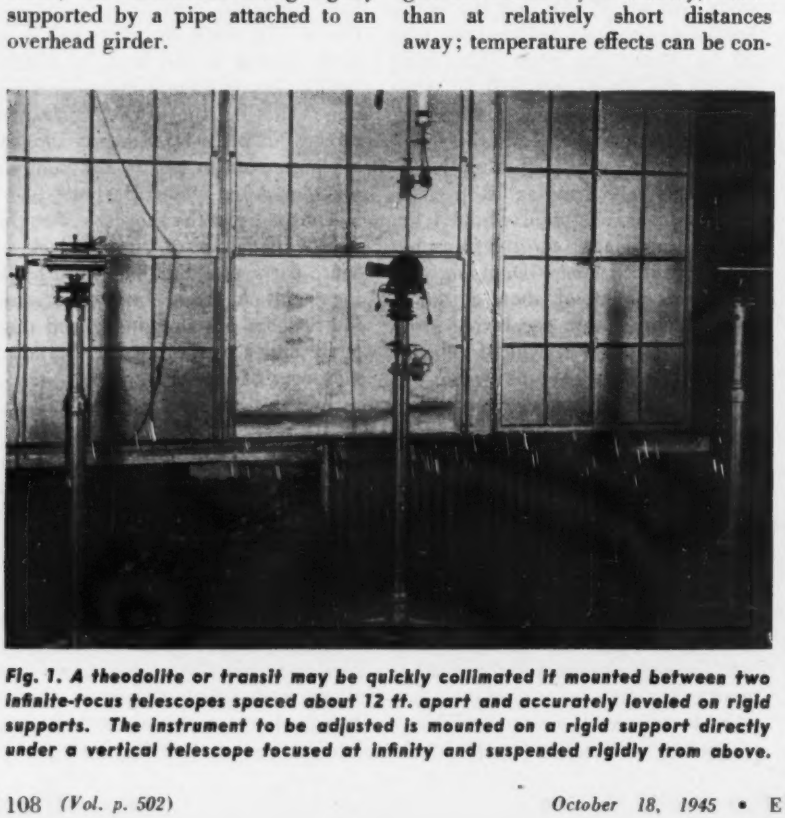


Fig. 1. A theodolite or transit may be quickly collimated if mounted between two infinite-focus telescopes spaced about 12 ft. apart and accurately leveled on rigid supports. The instrument to be adjusted is mounted on a rigid support directly under a vertical telescope focused at infinity and suspended rigidly from above.

Fig. 2. The horizontal telescopes employed are mounted on rigid supports with leveling screws that permit accurate control of the line of sight of the instruments.

In addition, the method results in a considerable time-saving in servicing the bureau's theodolites. Adjustment of an instrument outdoors by the previous method frequently required several hours. With the apparatus illustrated the work seldom takes more than an hour, and is frequently accomplished in 15 min.

Method becoming popular

Collimators are used in a somewhat similar way by the U. S. Coast and Geodetic Survey, while the General Land Office some time ago set up a room in which they employ collimators for adjusting solar transits. The highway departments of both Indiana and Mississippi use the method in maintenance and adjustment of surveying instruments, and Connecticut is training a man to do collimator work. Also, municipalities are beginning to utilize the procedure, Hartford, Conn., being at least one city now having a man trained in the shops of an instrument manufacturer for such work. The experience of these organizations, as we

as that of the Weather Bureau, indicates that the method has many merits. It is to be noted that other agencies planning to follow the procedure described could substitute wye levels for the collimators, which might reduce the investment in the equipment but would not eliminate any of the advantages cited.

The apparatus was built of available materials by the instrument division of the Weather Bureau, and is used in the bureau's laboratories at Washington, D. C.

Seabees Develop Machine To Paint Traffic Stripes

For use in maintaining the several miles of highway of a large naval operating base a maintenance unit of the Seabees built a machine to paint the center-line traffic stripe. Constructed at little cost with materials on hand, the machine has proven satisfactory from the standpoint of performance and in mileage covered in a given time.

Details of contraction

The carriage of the machine is the chassis of a discarded camouflage paint-spraying outfit with rubber-tired wheel-barrow wheels substituted for the original iron wheels. A small gasoline-engine - driven compressor provides air at a pressure of from 75 to 150 psi., the average working pressure being about 75 psi. A salvageable air tank of the proper size was not to be had, so a large tank was cut down and refabricated in the welding shop. This tank is mounted on the carriage behind the compressor.

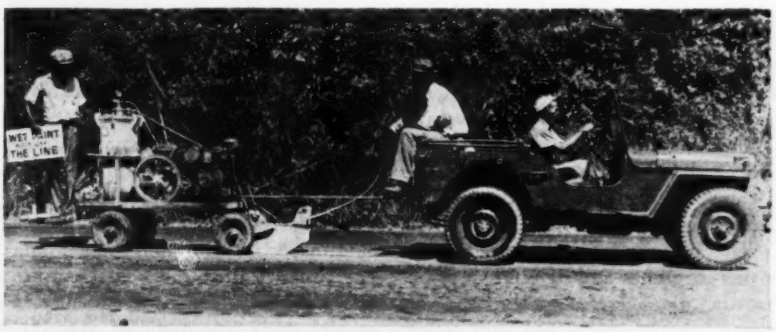
A small pressure tank in which paint is added rests in a steel collar welded to a platform over the air tank and supported by steel legs welded to the carriage. An average pressure of from 50 to 60 psi. is maintained in the paint tank when the unit is operating.

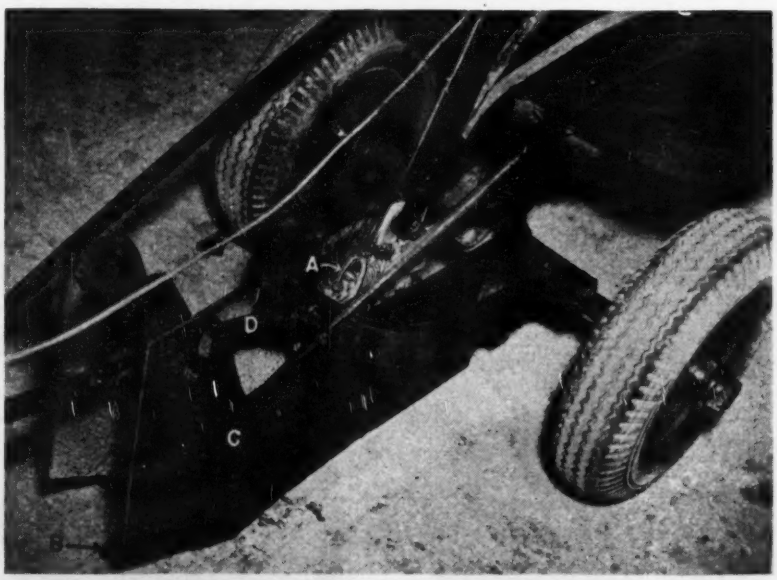
The paint and air flow under pressure from their respective tanks through hoses terminating in a No. 76 spray nozzle marked A, (shown in detail below) which discharges in the form of a stripe through the bottom of the 5-in. wide paint guide marked C. The spray nozzle is mounted on a bracket at the end of the guide, and may be detached by removing one bolt. To clean the roadway in front of the machine, air flows directly from the air tank through a hose to discharge at the opening designated B. A valve at the tank end of this hose permits a pressure of 10 psi. to be maintained at point B. The steering rod D is controlled by an operator who rides on the rear of the jeep, to which the machine is connected by means of a rigid tow rod terminating in a ball-swivel attachment.

The paint guide, made of a ¼-in. steel plate, extends forward from the front axle, to which it is welded. For additional rigidity, the guide also is welded to a U-shaped bracket in turn welded to the front axle.

The paint spray nozzle is operated by a man on the rear of the towing vehicle by means of a heavy cord leading from the trigger of the nozzle to the handle of the steering rod. A man riding on a low platform at the rear of the machine regulates the pressures in the air and paint tanks.

This article is an abstract of a description that appeared in a recent issue of *Construction Battalion Activities* published by the U. S. Navy.





Job-made paint machine (shown at top) built by the Seabees is compact and easy to operate. In addition to driver of jeep towing unit, only two operators are required. The man on the back of the jeep steers the machine, while the operator at the extreme left regulates the pressure in the air and paint tanks. Air discharged through pipe designated B in lower picture cleans pavement previous to application of paint.

Probable Life of Corrugated Culverts

George E. Shafer
Chief Engineer

W. J. Kroff
Sales Engineer

Armco Drainage Products Association

***Contents in Brief**—A survey of the performance of more than 800 large, corrugated iron plate pipes and arches serving as culverts indicates a life expectancy for the pipes of at least 50 years, while for the arches there was not sufficient measurable deterioration on which to base a prediction. In general, the life of a corrugated arch will be determined by its foundations. Other survey results are of value in determining how to use corrugated pipes and arches more effectively as drainage structures.*

RECENTLY a field inspection was made of large-diameter corrugated metal plate drainage structures to check design data, study material performance and gather information of value both to the manufacturer and the user. As a result of this survey, the factors influencing the performance in service of these culverts have been determined and their life expectancy estimated.

The installations examined consisted of arches and of pipes over 60 in. in diameter, all composed of heavy, curved galvanized iron plates with 6 x 1½-in. corrugations, assembled by bolting in the field. The large-diameter, corrugated pipes had been introduced for use as culverts in 1931, and to meet a need for low, wide openings, arches were tried out the following year.

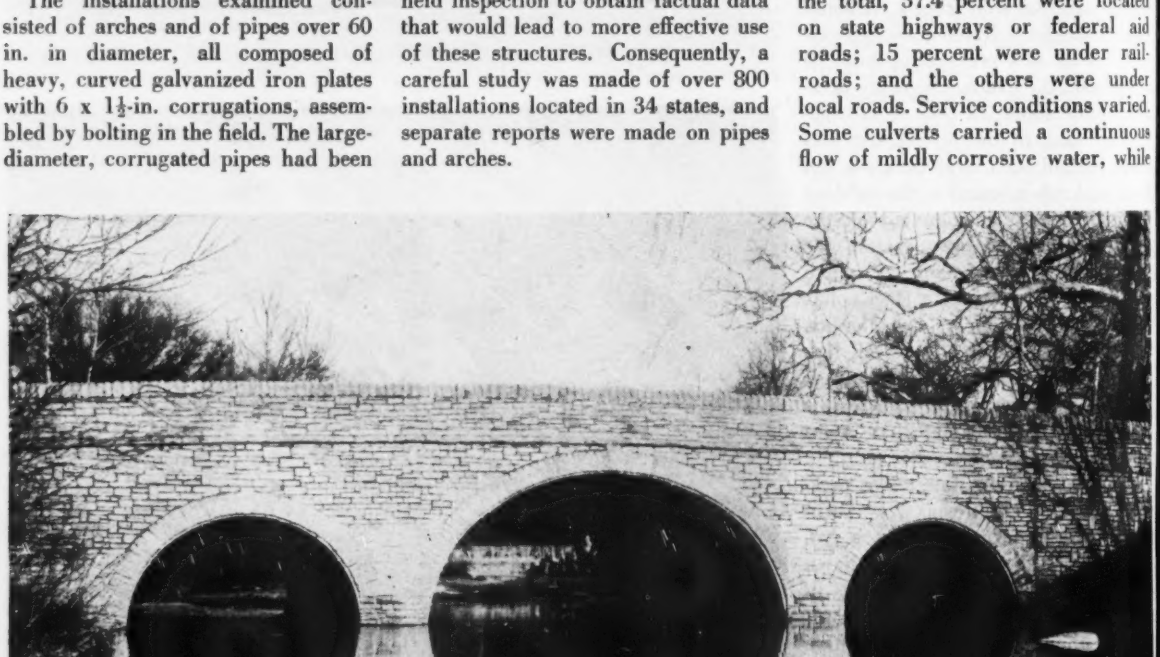
Prior to 1943, only limited inspections to check design data had been made. After the initial 12 years of service, the Armco Drainage Products Association, originators and manufacturers of these corrugated culverts, decided to sponsor a large-scale field inspection to obtain factual data that would lead to more effective use of these structures. Consequently, a careful study was made of over 800 installations located in 34 states, and separate reports were made on pipes and arches.

To secure the desired information and uniformity of results, comprehensive inspection forms were devised. Full use was made in drawing up these forms of the experience gained in a nationwide inspection of over 12,000 small culvert pipes completed in 1931 in cooperation with various state highway departments and the Highway Research Board.

The study was divided into pipe installations and arches. Below is given a summary of the findings with respect to pipes, and following that is comment on the arch culverts.

Findings with respect to pipes

A total of 355 pipes ranging in diameter from 60 in. to 180 in. and located in 34 states were inspected. Of the total, 37.4 percent were located on state highways or federal aid roads; 15 percent were under railroads; and the others were under local roads. Service conditions varied. Some culverts carried a continuous flow of mildly corrosive water, while



A triple-span arch, installed in 1932 and still in excellent condition 12 yr. later, is typical of older arches inspected.

others were subject to occasional erosive runoffs from semi-arid mountainous country.

Age of the pipes ranged from 4 to 13 yr., with the average being 7.7 yr. Approximately 44 percent of the total were 8 or more years of age. Greater numbers in the older age groups were in service, but lack of time and travel restrictions limited the number studied.

Material Performance—While the comparatively small number of installations inspected and the wide variation in service conditions do not permit drawing definite conclusions as to material performance, the results do, however, indicate in a general way the life which might be expected on an average.

The following method was used to secure a rough estimate of the probable life: First, the various easily-recognized stages of material condition, as reported, were assigned numerical ratings. Then, the weighted averages of these ratings were computed for the age groups from 4 to 12 yr. inclusive and plotted against age. Finally, the line determined by the points thus established, when projected to a zero rating, indicated an average life expectancy of at least 50 yr. for the inverts of the pipes for all gages and all conditions of service.

The above figure is recognized as being only a rough estimate. First, it is based on a hindsight of only 8 yr. Second, no attempt was made to separate the pipes according to gage, which varied from No. 10 to No. 1 ($\frac{7}{64}$ in. to $\frac{9}{32}$ in. thick). Third, while the numerical ratings for various condition classifications were established as carefully as possible, repeat inspections of the same installations three or four years later will be required to establish definitely their accuracy.

Only structures where circumstances permitted a thorough examination were included in making up the weighted averages, and the material ratings were based on the worst condition and not on the average condition of the entire structure. With these precautions in mind, the estimate of an average life of at least 50 yr. for all gages and all conditions of service may be said to be a conservative one based on the most complete performance data which could be secured.

Another matter to be considered in interpreting the 50-yr. probable life is that large corrugated pipes, because of their size (82 percent of those inspected were 90 in. or more in diameter) carry more water and more abrasive materials than small culverts. Roughly, three-fourths of the pipes inspected were reported as serving under erosive or a combination of corrosive and erosive conditions. Wear was concentrated in the bottom of the pipes, in many cases being confined solely to the invert plate. Furthermore, lack of evidence of outside corrosion indicates that this type of deterioration has been effectively countered. Thus, the condition of localized wear indicates why, in analyzing performance records, pipe drainage structures in this size range must be grouped in a class by themselves.

In large pipes, the need for balanced design to meet bottom wear conditions is accentuated. The construction of these corrugated pipes is such that the balanced design required to effectively satisfy the above described service conditions can be attained easily. An economical solution is to call for heavier plates in the invert than are required by strength considerations alone, the number and gage of the heavier plates to be used being determined by the size of pipe, the service conditions to be met and the length of life desired. The extra life gained will far outweigh the small additional cost of the extra material.

This 105-in. pipe, installed under a Colorado highway with an 84½-ft. fill, had a maximum deflection of 6 in. but was in good condition structurally after 6 yr. of service. Severe erosive and continuous flow have removed the spelter for a width of 2 ft. in the invert, but there was no appreciable loss of base metal.

Structural Performance—Loading conditions on the pipes inspected ranged from main-line railroad traffic and comparatively shallow cover to fills up to 84½ ft. high, with 24.2 percent of the culverts serving under fills 20 ft. or more in height. The structural condition of the pipes was good, especially so, considering the loads and foundation conditions under which many were serving. This fact indicates that design recommendations are adequate.

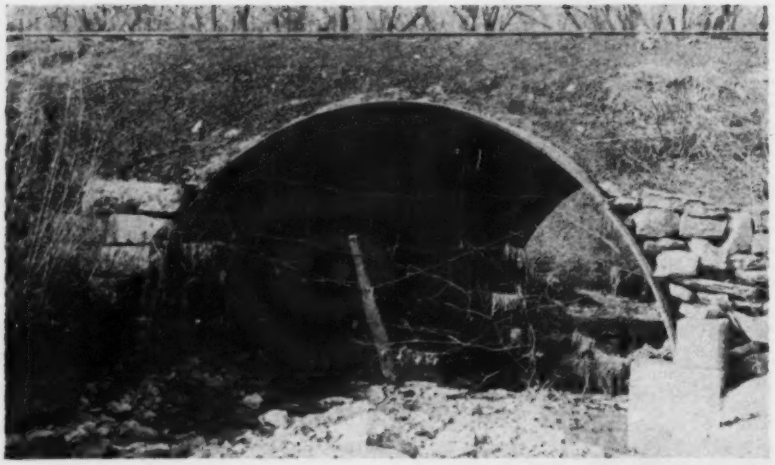
In the relatively few cases where structural performance was not 100 percent satisfactory, the condition of the structures could be traced to a failure to comply with some of the conditions on which the design data are based. This indicates the importance of full compliance with all the design recommendations.

Miscellaneous Observations — In spite of the comparatively short period of time, 15 yr., in which this type of pipe has been in service, 25 percent of the installations inspected had either been extended or relocated. The value of 100 percent salvagability and ease of making positive extensions is thus demonstrated.

In about 28 percent of the total inspected, the construction of headwalls was eliminated by beveling the ends to fit the slope. Other types of end finish used were square ends with or without riprap, and headwalls of metal, concrete, masonry or wood, both full and half height. Existence of such a variety of end treatments indicates the value of a continuous construction that permits using an end finish best meeting prevailing conditions and utilizing available local materials.

Almost one-sixth of the pipes had fill heights of 2 ft. or less. This indicates the need for a pipe-arch type of structure in the larger size ranges that has all the advantages of pipe plus superior hydraulic characteristics and better adaptability to locations with limited headroom.

About one-third of the 479 corrugated iron arch installations inspected



Replacing a railroad trestle in 1932, this 15-ft. span, No. 3 gage arch after 12 yr. of service was in excellent condition structurally.

were 9 or more years of age, with the average of those rated materially being 7.8 yr. Twenty-one percent were located on state or federal aid highway systems.

Arches make a good showing

Material Performance — Service conditions for arches, with respect to the effect on the plates, vary greatly from those of pipes. Arches, except for a few in the smaller sizes, have no bottom except the streambed, and where possible, the springline of the arch is usually kept above the normal water level. Thus, in most cases, only during flood time is the stream side of the plates in direct contact with water. Very rarely do arch culverts suffer from erosion. Insofar as the plates are concerned, therefore, the principal factor controlling the life expectancy of arches is outside corrosion.

Although special effort was made to discover any evidences of outside corrosion, the results of the inspection indicate that it is not of appreciable magnitude. There were a comparatively few instances of seepage at the bolt holes, but at worst this merely marred the appearance of the structures. Except in a few isolated cases with a corrosive backfill, no evidence of outside corrosion was found. These findings check with the much longer service record of riveted corrugated pipes, where it has been found that when normal, non-corrosive backfilling materials are used, outside corrosion presents no problem.

Taken as a whole, the material condition of the structures inspected was very satisfactory. When the weighted average ratings for the various age groups were plotted against their age, as was done for pipe, there was not sufficient measurable deterioriation to make any attempt at projecting the probable life expectancy. Because of the uniformly good material condition of the arches, it is believed that in the majority of cases, the life of corrugated arches will be determined by the life of the foundations.

Structural Performance—Loading conditions on the arches inspected ranged from railroad traffic with a cover of only 3 ft. to highway fills up to 25 ft. high. Spans ranged from 5 ft. to 27 ft.

Structurally, 92 percent were rated as good or better. In no single case was a report made that would indicate that an installation was in distress structurally. This indicates that design recommendations as to gage, fill height, span and live load are satisfactory.

Five-sixths of the arches inspected were installed on concrete-abutment type footings, and no single instance was reported where the footing showed any indication of overturning due to lateral pressure. Where foundations were reported as unsatisfactory, the causes were undermining or poor quality of material used. This indicates the soundness of the footing design data provided.

Miscellaneous Information—When metal seats were used in an arch installation, they were standard angles and channels or a special unbalanced channel with anchoring devices. Construction without metal seats consisted chiefly of a groove or an offset cast in the footing to resist the side thrust at the base of the arch.

With a view toward reducing the cost of construction, the part of the reports dealing with the condition of footings was carefully analyzed to determine whether it would be practical to dispense with metal seats particularly in the smaller sizes. Installations, both with and without metal seats, were subdivided into groups according to age and size, and the reported footing conditions carefully compared. This analysis showed no appreciable difference in the footing conditions that could be attributed to the use of a metal arch seat. Thus, the conclusion is reached that it would be safe to eliminate the metal seat for arches up to and including 15-ft. spans.

Where non-draining arch seats are used, it has been recommended that they be filled with asphalt or some other resilient waterproofing material. In a few instances, failure to do this resulted in corrosion at the base of the arch, and in northern sections, freezing of retained water caused spalling of the concrete.

With regard to other structural details, it should be noted that one out of every five structures was skewed. The reports show that skewed installations are both practical and safe, if the recommended precautions for supporting the cut edge of the plate with hook bolts and properly designed headwalls are observed, or if a length sufficient to prevent live loads from coming on the unsupported edge of the plates is used.

Headwalls where hook bolts were used showed up to a slight advantage over those without. This was particularly true of skewed installations. For this reason, the use of hook bolts is recommended, as their cost is slight considering the benefits gained.

About one-half of the arches inspected had masonry headwalls, slightly more than one-third had concrete headwalls, and the remainder had riprap, dry rubble, metal, or no end finish. This adaptability to a wide variety of end finish was found to be a valuable feature, both from the standpoint of appearance and utility.

The data obtained in this survey, while not conclusive, is nonetheless indicative of the performance to be expected of the culvert types studied. It is hoped that this inspection and its conclusions will be of assistance in making more effective use of corrugated pipes and arches.

A Special Section On...

PEACETIME BUILDING

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NEW PRACTICES AND PRODUCTS

Cutting Costs With Modular Design

A. Gordon Lorimer
Chief, Bureau of Architecture, Dept. of Public Works
New York, N. Y.

***Contents in Brief**—A module of 4 in., selected as the basic dimensional unit for all building products, serves as the spacing for a 3-dimensional grid to which a building and its components may be referenced. In coordinating products, the nominal dimensions are in multiples of 4 in. but allowance is made in the actual size for joints. Modular coordination introduces economies in building construction through production standardization, prefabrication, simplification of designs, reduction in number of jobs operations and saving in construction time.*

THE BUILDING INDUSTRY is not a closely knit organization but is composed of thousands of manufacturers of a multitude of building products and workers of many trades or crafts. Some building materials have been used for many centuries, and their dimensions are often based on outmoded conditions. Other more recent materials have developed under modern industrial methods and are generally of controlled dimensions.

In the first group, we have brick and other masonry products, while the latter types include sheet asbestos, insulating boards, acoustical tile and stock fluorescent lighting troffers. Practically all of the first category, and even some of the second, have been developed with dimensions convenient for manufacture rather than for integration with other products required in building. The result is that much time-consuming cutting, fitting and patching is required on the job to bring all these elements together into a completed building.

One has only to examine the brickwork at the jamb of any window to see that cutting of the brick was required to produce the required opening for the frame (Fig. 2). Similarly, in interior work, one constantly finds that extremely hard materials, such as glazed and unglazed structural facing tile, used in stairhalls and toilets, required laborious cutting by carborundum wheel around stair stringers, doors, recessed firehose cabinets and windows.

Fig. 1. Uniform spacing of elements of this building is a good example of the trend toward coordinated design.

The causes of this extensive field cutting may be determined by considering a usual type of construction. In a section of wall one commonly finds three masonry materials—face brick, back-up tile or block, and interior glazed structural facing tile. Generally, until now, these have each been made in exact multiples of 4 in. At first glance, this would seem quite proper until one realizes that the exterior brick may be of rough texture and character requiring ½-in. joints, the back-up block may be laid with ⅜-in. joints, while the interior glazed units, being of more finished character, are generally set with ¼-in. joints.

Obviously, to produce a given size of pier one material or the other must be cut. Actually, windows have not been generally coordinated to masonry, and it has often been necessary to cut all three materials to produce a proper window opening.

Find four-in. dimension prevalent

In 1938, the Producers' Council and the American Institute of Architects, recognizing this fault in construction, jointly sponsored Committee A62 of the American Standards Association for the study of dimensional coordination. Investigation of the building field showed the almost universal prevalence of the 4-in. dimension. It is inherent in standard wood framing with stud and joists 16 in. on center and in sheet materials such as plaster board, plywood and insulation boards, which are made 48 in. wide to permit nailing to 3 studs 16 in. o.c. It is also found in the commonly used 12 x 12-in. acoustic tiles and in the more recent 12 x 48-in. fluorescent lighting troffers.

Hence, it was inevitable that the 4-in. module was selected as the basic dimensional unit for coordination of all building products. It most easily conforms to present building habits yet permits a logical development of new coordinated products.

Module is basis of reference grid

This 4-in. module is used as a dimensional increment or multiple. It serves as the spacing for a uniform three-dimensional grid to which the building and its components may be referenced. Taking brick as an example, we see how the grid determines the size of the brick as well as its location (Fig. 4). In a similar manner, we arrive at the relationship between all modular products.

On the one hand, this three-dimensional grid provides the designer with a simple, convenient and uniform method of referencing all elements of the building, and on the other hand, the grid also guides the manufacturer in determining the coordinated sizes for his products. The component parts of the building are thus related to a common measure and brought under a uniform control.

Actually, it is not necessary to draw all the grid lines on a small-scale plan as the grid is literally on the architect's scale. Grid lines are a most vital aid, however, in larger scale details of controlling conditions.

Consideration of the progress made in the adoption of modular products quite properly should begin with glass blocks. When these were introduced on the building market some years ago, the principles of modular products were anticipated at the instigation of Fred Heath. Glass blocks were given nominal sizes of 8 x 8 in. and 12 x 12 in. but actually, they were designed to be laid with ¼-in. joints, and the blocks were made 7¾ x 7¾ in. and 11¾ x 11¾ in.

Principle of coordination

Here we have, therefore, the first conscious adoption in manufacturing of the principle of dimensional coordination of building products; viz., *the unit of repetitive growth of any product should include within its nominal dimension an allowance for the joint necessary to connect one unit to the next.*

The administration building of the Sperry-Gyroscope plant on Long Island, planned by Nembhard N. Cue-

Fig. 2. In a recently constructed building, every jamb brick in every course had to be cut, completely unnecessary waste.

lin, designer and Stone and Webster, engineers, (Fig. 1 and 3), is an excellent example of integration of glass block with other modern building products, such as 12 x 12-in. acoustic tile and 12 x 48-in. fluorescent lighting troffers. An accurate rhythm is maintained between these elements, the structural frame of the building, and even mechanical items such as the air-conditioning outlets.

The Structural Clay Products Institute, a national organization of manufacturers of brick and structural clay tile, has adopted modular standards for the production of brick and structural tile, in which the required joint is in all cases allowed for in the production of the unit. For example, a brick nominally 8 in. long and of a soft-mud type requiring ½-in. joints is made 7½ in. long while a glazed brick of stiff-mud clay will be 7¾ in. with ¼-in. joints. These, then, may be easily combined in one wall as the unit of growth, or increment, in each case, is 8 in. The producers of concrete masonry units have similarly adopted coordination and are providing for the required ⅜-in. joint by producing 8 x 16-in. nominal blocks with 7⅝ x 15⅝-in. dimensions. The above products may be combined to produce a coordinated wall.

Window dimensions coordinated

The Steel Window Institute followed with the adoption of standardized solid-section steel windows, coordinated on 16-in. multiples vertically and 20-in. horizontally. For the first time, interchangeability of window types and windows of different manufacturers was achieved.

Previously, the various types of solid-section steel windows, such as architectural projected and factory projected, were not interchangeable in the same opening. If, for reasons of economy, it was decided to change from one type to another, the architect's working drawings had to be changed, and at times even main

Fig. 3. Integration of modern building products—glass block, acoustic tile, lighting troffers and air conditioning outlets—is evident in interior of administration building, Sperry-Gyroscope plant, Long Island, N. Y.

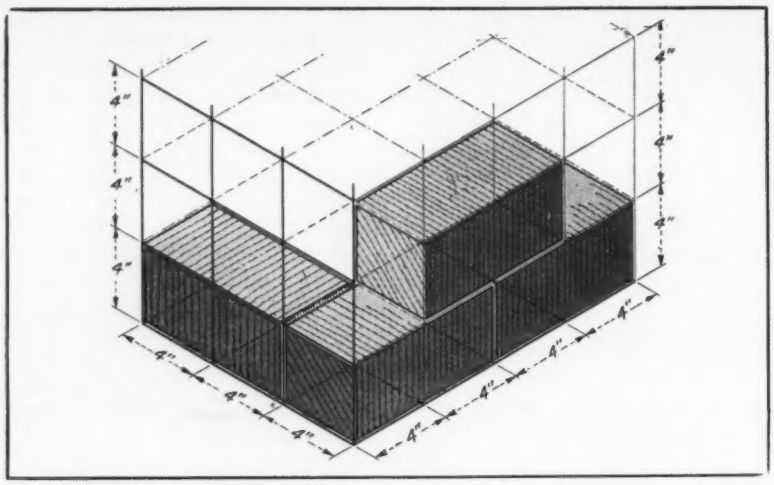


Fig. 4. Typical of how the modular grid is utilized is this illustration of how it determines the size and placing of bricks. Note centering of joints on grid lines.

building elements had to be adjusted. Through dimensional coordination, all types of solid-section steel windows and the products of all manufacturers are now interchangeable in the same masonry openings.

In the manufacture of wood double-hung windows, there used to be some ten different "markets" or regions throughout the country. Each of these markets had varying methods of calculating the wood margins surrounding the glass, with the result that windows were not interchangeable from market to market. Through dimensional coordination, nationally standardized wood double-hung windows are now available in 4-in. increments, fitting not only coordinated brick openings, but also well adapted to wood-frame construction.

Standardization of metal and wood windows opens up for the first time a large and reliable market for stock sills and lintels of cast stone or concrete, as well as production standardization of the natural materials, such as slate, stone and marble.

Manufacturing costs may be cut

Great economies lie not only in production standardization as such, but also in ability of the quarry or shop to produce regularly throughout the year with more stable return on capitalized cost of equipment and with better labor relations through steady employment.

It is possible that some of the natural-materials industries, such as marble and granite producers, will again compete with synthetics due to improved production means and year-round stabilization by production of coordinated, standard-size veneers, copings and sills. One large granite producer has already led the way with an intelligent study of coordinated slabs and sections, available in 4-in. modular sizes through multiple gang-sawing of the basic quarry block.

The excellent weathering qualities of many natural materials might be utilized in a manner consistent with modern building techniques by adequately backing large slabs of thin veneers with cast material of high insulating value. This would achieve the two main characteristics sought in an exterior wall—weather resistance and low thermal conductivity.

Steel framing accents grid

Now, how will modular coordination affect the engineer? In steel framing, the general layout will differ little from present practice. Column spacing will generally be even foot multiples of 16, 18, 20, 22 and 24 ft., and in many buildings the steel framing will merely represent a major accenting of the 4-in. grid in much the same way as graph paper is accented at regular intervals.

It should be remembered, however, that such even foot spacings are a general convenience rather than a necessity imposed by dimensional coordination. A bay spacing of 28 ft. 4 in., for example, is just as much a coordinated dimension as 20 or 22 ft. and will permit the use of coordinated masonry materials and windows.

Many designers use this accented "major module" as a space planning convenience. For example, in hospitals it is convenient to use a structural bay of 22 ft. for each typical "Riggs" ward of 6 beds. This unit is conveniently divisible into two semi-private rooms of 11 ft. and into convenient treatment and utility rooms. (Fig. 6.) It should be noted that in such cases, the 22-ft. bay is established primarily as a proper space subdivision for the special function of the building. Where such subdivision also coincides with a desirable structural spacing of columns, maximum economy obtains.

An excellent example of the trends towards coordination on the "major module" is the Murray Hill unit of Bell Telephone Laboratories, designed by Voorhees, Walker, Foley & Smith, architects. Here a repetitive unit of 6-ft. width was adopted, comprising one pier and one double-hung window. Each unit was provided with complete service lines, which permitted laboratories of 12-, 18- or 24-ft. width within a 24-ft. structural bay.

Future of prepared units predicted

For such recurring types, therefore, there is probably a good field for development of all forms of prefabricated steel deck-type floors and, of course, for precast concrete floor units. Even in conventional job-poured concrete construction, dimensional coordination should pay dividends. American construction has in the past been almost criminal in its careless and wasteful use of lumber in formwork, and a method of better organization of form dimensions is a long-felt need.

With the recent introduction of vacuum methods for speedy curing, and improved methods of electrical prestressing, and pressure molding, very promising possibilities are opened for long-span precast floor sections. Obviously, an organized method of dimensional coordination is required throughout the entire structure to fully derive the benefit of such prefabrication. Modular design provides the proper framework.

Costs reduced by duplication

We are all aware that mass production means low cost, but few architects and engineers are actually conscious of the vast cost differences resulting from even a moderate degree of repetitive manufacture. The writer

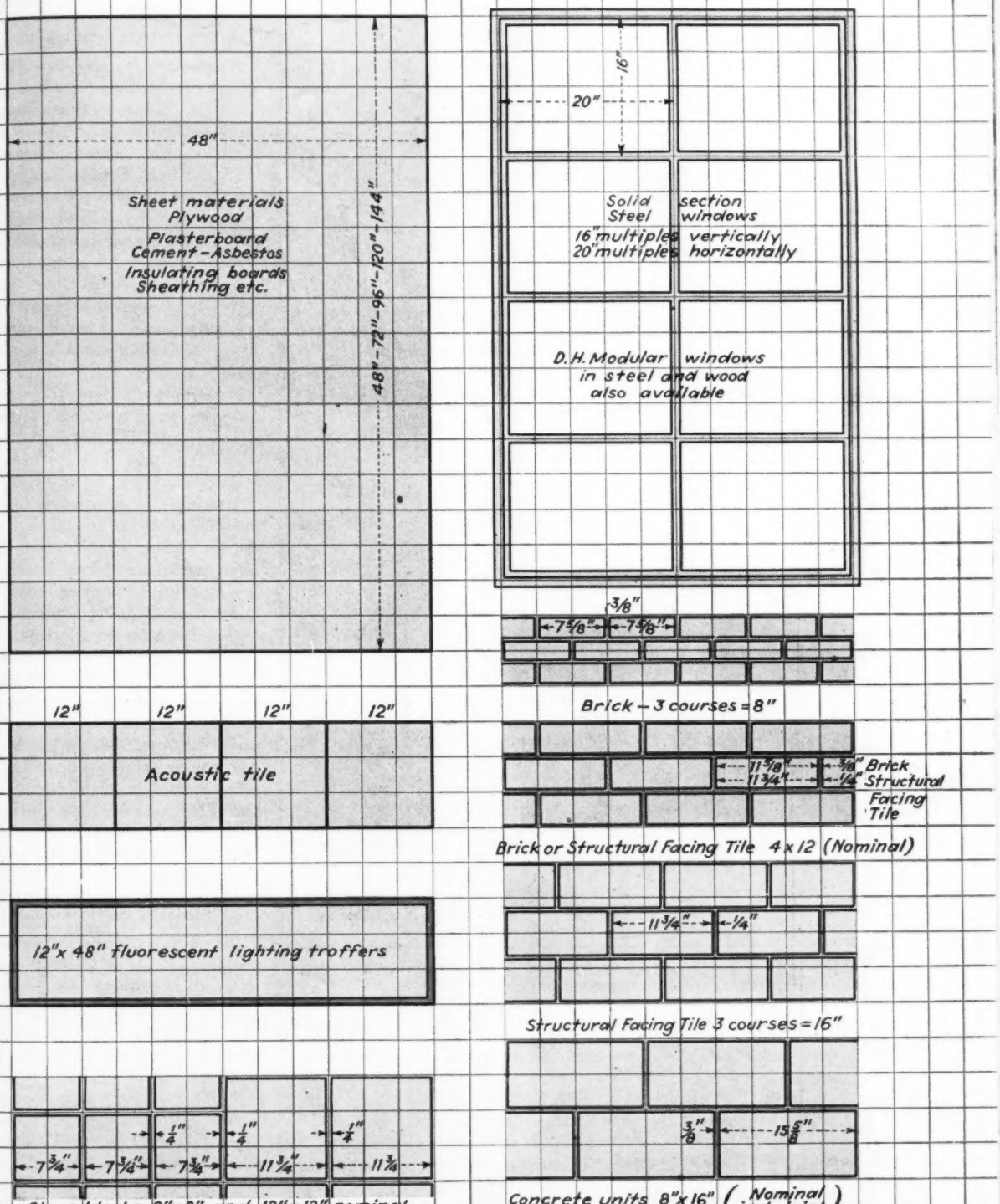


FIG.5 Types of building products that have been dimensionally coordinated

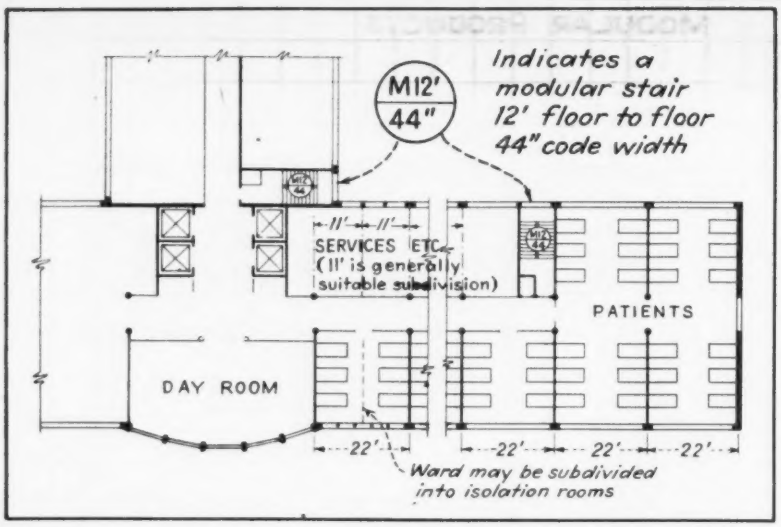

M12'
44"
Indicates a modular stair 12' floor to floor 44" code width
11' 11'
SERVICES ETC. (11' is generally suitable subdivision)
PATIENTS
DAY ROOM
22' 22' 22' 22'
Ward may be subdivided into isolation rooms

Fig. 6. Example of use of major modules is 22-ft. structural bay for typical 6-bed hospital wards. Standardized stairs are referred to by key number.

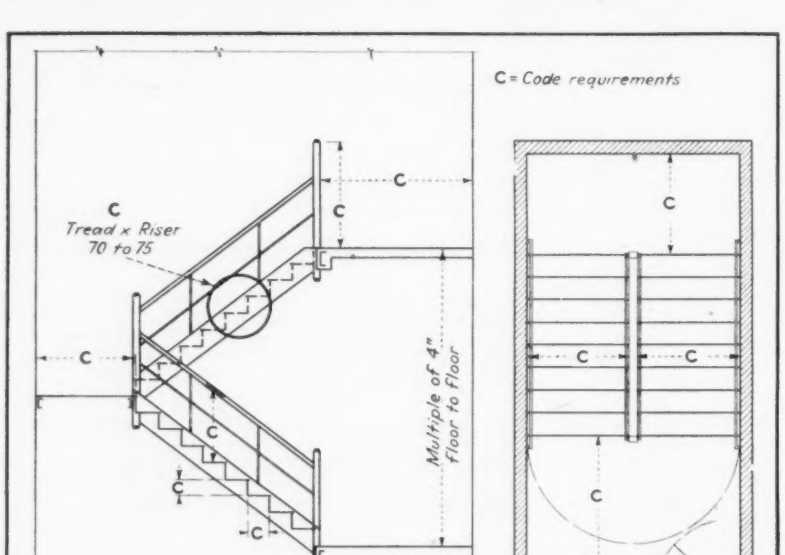


Fig. 7. Requirements of building codes control stair, landing and door dimensions. Hence, stairs may be standardized on modular basis.

had occasion recently to question a leading manufacturer of metal hospital equipment as to why equipment costs were so high in a certain hospital. He produced some staggering facts.

The actual shop drawings showed some very slight variations in size of cabinets performing identical functions. Such variations are apt to occur where the space between column faces increases from floor to floor as the columns diminish in size due to reduced loads, and where for sanitary reasons the cabinets must be kept flush with the columns.

This manufacturer produced a carefully studied price sheet giving the make-up cost of one single specially dimensioned drawer as $20.20. When 6 identical drawers were required, the cost dropped to $9.25 per drawer, and when the order was for 150 or more, the cost dropped to $2.80—less than 1/7 of the cost of the single special unit. One can readily imagine the high premium that has until now been inherent in the multiplicity of unstandardized units found in most architectural work.

Paring construction time cuts costs

The steadily rising costs of field labor, overhead and insurance point to the need for reduction of total construction time. In traditional construction, the various phases of the work, such as foundations, skeleton frame, floor slabs, partitions, finishes, equipment, have followed each other in separate stages with the total construction time approaching the aggregate of the individual times. Particularly in regard to special built-in equipment, such as for hospitals and kitchens, it was often necessary to wait until the rough work of the job was completed, then take accurate field measurements, make detail shop drawings, individually mark and ship each item, and follow through to installation.

Reducing total construction time, modular design will give impetus to the simultaneous fabrication of floor units, partitions and equipment while the foundations and main frame are under way. It is true that this trend is already under way, independent of the use of modular products, but dimensional coordination with products all related to the 4-in. module makes the process more logical and more easily managed. Also, repetitive manufacture is necessary to achieve the full benefit of the prefabrication process. This wide market is obviously only possible through the use of a common denominator, such as the 4-in. module.

Standard stairs considered

Let us examine a typical case where prefabrication can be used to advantage. While stairs are generally fabricated in time not to hamper the progress of construction, they are, nevertheless, a burdensome chore to the architect. In the modern multi-story building, stairs are used primarily as a safe means of egress in the event of fire or other calamity. As such, they are carefully specified under the building codes as to widths, size of treads and risers, landings and doors (Fig. 7). Yet, architects keep detailing and redetailing them job after job, while the fabricator has to make

endless shop drawing submissions with ensuing delay.

There is no reason why stairs for certain commonly repeated floor to floor heights cannot be standardized on a modular basis. The architect should have to do no more than refer to the controlling over-all dimensions and provide for and refer to same in his planning, using a proper key number to indicate the required stair.

What would this acceptance of standard sizes mean to the stair manufacturer? In addition to being relieved of costly shop drawings, he could afford to really study his stair for the utmost in service and economy of construction, knowing that this study would be applied to hundreds or thousands of stairs, whereas it obviously is not possible to devote much time to individual cases.

Everyone, therefore, benefits—the architect is relieved of a tedious task and given more freedom for research and design; the contractor has less headaches with unexpected conditions; and the client has saved money.

Elements not limited by module

A rather common misconception of dimensional coordination and the 4-in. module is that all walls, partitions, floor slabs, and beam depths must be multiples of 4 in. Obviously, to do this would often mean wasteful use of structural materials and needless weight added to the building.

It is important to remember that any system of coordination is the servant of the designer toward better achieving his ends. Immediately the designer blindly permits any system to control his actions, he is abusing its prime purpose. It should be clearly remembered that the three-dimensional grid on 4-in. centers is a convenient means of referencing in three dimensions all the components of the structure in the same way that cartesian coordinates are used in defining in two dimensions an objective on a military map.

Thus, it may often be structurally sound to use 10-in. exterior walls or 3-in. interior partitions, and so long as these are consistently referenced to the grid, then their exact relationship may be easily detailed. In such conditions, an alert designer will hold the more expensive and hard materials to exact relationships in 4-in. multiples and will permit the take-up to be made in the more plastic materials, such as concrete or in plastered partitions. Fig. 8 shows how the differential might be taken up between the actual required structural thickness of a slab and the modularly controlled position of a glazed structural clay wall unit.

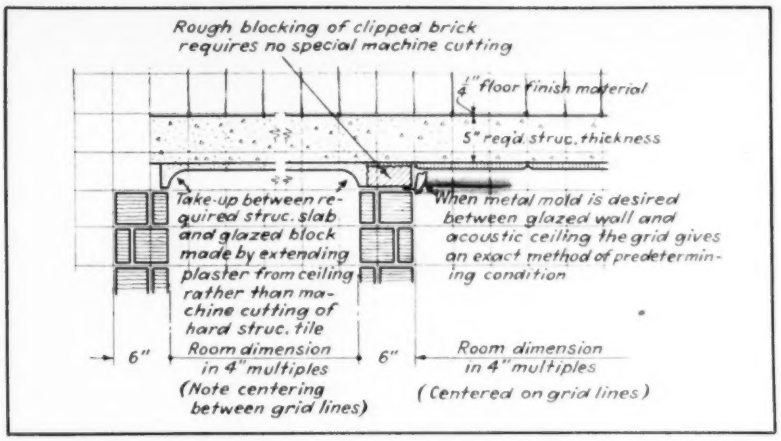

Rough blocking of clipped brick requires no special machine cutting
4" floor finish material
5" req'd struc. thickness
Take-up between required struc. slab and glazed block made by extending plaster from ceiling rather than machine cutting of hard struc. tile
When metal mold is desired between glazed wall and acoustic ceiling the grid gives an exact method of predetermining condition
6"
Room dimension in 4" multiples
(Note centering between grid lines)
6"
Room dimension in 4" multiples
(Centered on grid lines)

Fig. 8. Since slab dimensions are determined by structral considerations and wall units are modularly controlled, adjustment must be made at intersection of floor and wall. Grid lines are convenient in studying this condition.

Similarly, it is not expected that columns will always center on grid lines. Special framing conditions will still arise making it desirable to offset certain columns. Again the grid gives a convenient and speedy method of accurately detailing the proper dimensional conditions to produce the desired offset.

The Modular Service Association, which has acted as a study and secretarial service for Committee A62, is now engaged in the preparation of a manual for drafting room use that will give convenient solutions to recurring problems and show the most convenient methods of approach to new problems.

A question frequently asked about modular design is the following: If standardization is being adopted, why not go right to the metric system once and for all? Though the war undoubtedly brought a greater knowledge and use of the metric system, it may be a long time before the United States takes such a step nationally. Until such time, it is felt that the building industry will continue the present system of feet and inches.

It should be noted, however, that the modular system in feet and inches is actually in extremely close relationship to the metric system. The 10 cm. module already commonly used in French constructions is 3.937 in. or less than ⅛ in. different from the 4-in. module. Should the metric system eventually be adopted in America, the transition should be relatively easy.

Many millions of dollars in postwar projects to be constructed by the City of New York are now under design for the use of modular products. These include large hospitals, courts, health centers, markets, garages, fire and police stations, and buildings of the proposed Brooklyn civic center.

Use of modular design increasing

Large architect-engineer firms are now designing industrial work on the modular basis, and every day new interest is being shown by manufacturers in carrying the production of modular products beyond the exterior materials now available into all phases of equipment and furnishings. At present, exhaustive studies are being made toward the national standardization of kitchen cabinets and related equipment such as ranges and refrigerators.

To sum up—there is enough specific progress in modular materials to warrant modular planning by every architect and engineer, and there are enough projects now under design to warrant the adoption and production of modular products by the manufacturer. Speedy adoption of modular design and dimensional coordination by the building industry will pay dividends through better buildings in less time for less money. This in turn would stimulate more stable employment in the building trades.

U. S. Navy photo.

Fig. 1. Typical of spans made possible by modern laminating techniques are the 120-ft. timber arches used for several Navy drill halls.

Wartime Innovations In Timber Design

Albert G. H. Dietz
Assistant Professor of Structural Engineering and Materials
Massachusetts Institute of Technology

***Contents in Brief:**—The increased allowable unit stresses used for wartime timber construction and now recommended for peacetime application are based on the use of stress-graded lumber and assume loads to be permanent. Provision is made for variations in those stresses for combinations of temporary and permanent loads. Laminated timbers are permitted higher unit stresses than solid, and in the design of composite beams the usual flexural formulas are modified by the introduction of form factors because of the different strengths of wood in compression and tension.*

WOOD CONSTRUCTION methods have been greatly developed and put to the test by wartime demands. Engineers designing for peacetime use, therefore, have a wealth of experience upon which to draw for information and guidance.

Wartime consumption of timber made it necessary to stretch the available supply to the absolute maximum. Hence, to effect greater economies in the use of wood, design loads were drastically reduced and allowable stresses for structural timbers were generally increased 20 percent in accordance with the provisions of War Production Board *Directive 29*.

The increased stresses do not appear to have resulted in generally dangerous structures in spite of the decreased design loads, the laxity in selection of structural material and the poor fabrication frequently inevitable under wartime pressures. Consequently, the increased allowable stresses are recommended by the National Lumber Manufacturers Association for normal peacetime designs with normal peacetime design loads.

Design based on stress-graded wood

Fundamental to all engineering design in timber is stress-graded lumber. The principles were well established before the war, and engineering timbers, carrying specified allowable stresses depending upon the stuctural grade, were generally available.

Stress-grades are now established for white ash, beech, birch, chestnut, southern cypress, tidewater red cypress, coast region Douglas fir, inland empire Douglas fir, rock elm, soft elm, black and red gum, eastern hemlock, west coast hemlock, hickory, larch, hard maple, red and white oak, pecan, Norway pine, southern longleaf pine, southern shortleaf pine, yellow poplar, redwood, eastern spruce and tupelo.

Structural timbers are classified as: Beams and stringers, intended to be loaded on the narrow edges; joists and plank, intended to be loaded on either the narrow or the wide edges; and posts and timbers, intended to be loaded along their axes parallel to the grain.

Values are specified for tension, extreme fiber in bending, horizontal shear, compression perpendicular and parallel to the grain, and modulus of elasticity. These are based upon the size and position of knots and splits of all kinds, upon slope of grain, upon wane, and in some instances upon the relative proportions of spring and summer wood (dense Douglas fir and southern pine).

Allowable stresses assume loads to be permanent and lumber originally either green or dry, but kept dry in use. Variations in allowable stresses are:

Snow load combined with dead load, 15 percent increase; wind or earthquake load combined with dead load, 50 percent increase; impact stresses 100 percent increase if impact plus dead and other live loads do not exceed twice the permanent-load stresses. When decay hazards exist, allowable stresses are reduced 10 to 33 percent depending upon the condition. Final sizes of timbers should be not less than that required for permanent loads alone.

The modulus of elasticity is assumed to be unaffected by any condition of loading. For L/d ratios greater than 11, columns are designed according to parabolic formulas or the Euler formula, depending upon the value of L/d.

In joint details the allowable shear is 50 per cent greater than the tabulated values. Reactions under concentrated loads are modified, depending upon the position of the load. For compression on surfaces inclined at an angle to the grain, unit stresses are computed by the Hankinson formula.

Reductions in shear are made for notches, depending upon the depth of notch. Allowances are also made for the length of bearing perpendicular to the grain, with increases up to 75 per cent permissible.

With these provisions, engineers can design timber structures on a sound and economical engineering basis. It must be emphasized, however, that the allowable stresses for stress-graded lumber and the design procedures evolved assume that designs are carried out by competent engineering talent and that adequate supervision is provided during the fabrication and erection of structures. Only under these conditions can efficiency and economy be secured together with safety.

Connectors are standard practice

Experience with certain wartime design practices justifies retaining them for peacetime use. For example, timber connectors, almost a novelty ten years ago, have now practically become standard practice in timber framing. Four types are in current use: Split ring—2½ and 4 in. (Fig. 3); toothed ring—2, 2½, 3½ and 4 in.; claw plate—2½, 3½ and 4 in.; and shear plate—2½ and 4 in. Of these the split rings are the most widely employed.

Design loads for connectors are based upon the species of wood; the moisture condition of the wood at the time of fabrication and during use; the condition of loading, whether permanent, intermittent, or impact; the thickness of the member, the number of connectors and the relative positions in the joint; and the direction of the load with respect to the direction of the grain.

Spacing, edge distances and end distances are determined by the load per connector, the character of the stress, the direction of the load with respect to the grain and the direction of the axis of a ring-pair with respect to the grain.

Glued laminated construction

The wartime requirements for large high-grade structural timbers that could not be satisfied by available solid timbers gave a strong impetus to the use of glued laminated members. (Fig. 2 and 4) Intensive development of this type of construction is still continuing, and design criteria are being established.

The decision to use laminated timbers in place of solid requires a careful balancing of the economics of one versus the other. Generally speaking, if a member can be made of solid lumber, it is cheaper to do so because dressing and scarfing the laminae may require as much as one-third more lumber than solid timber. The cost of glue is appreciable, and labor costs are obviously higher than for sawing and dressing solid timbers.

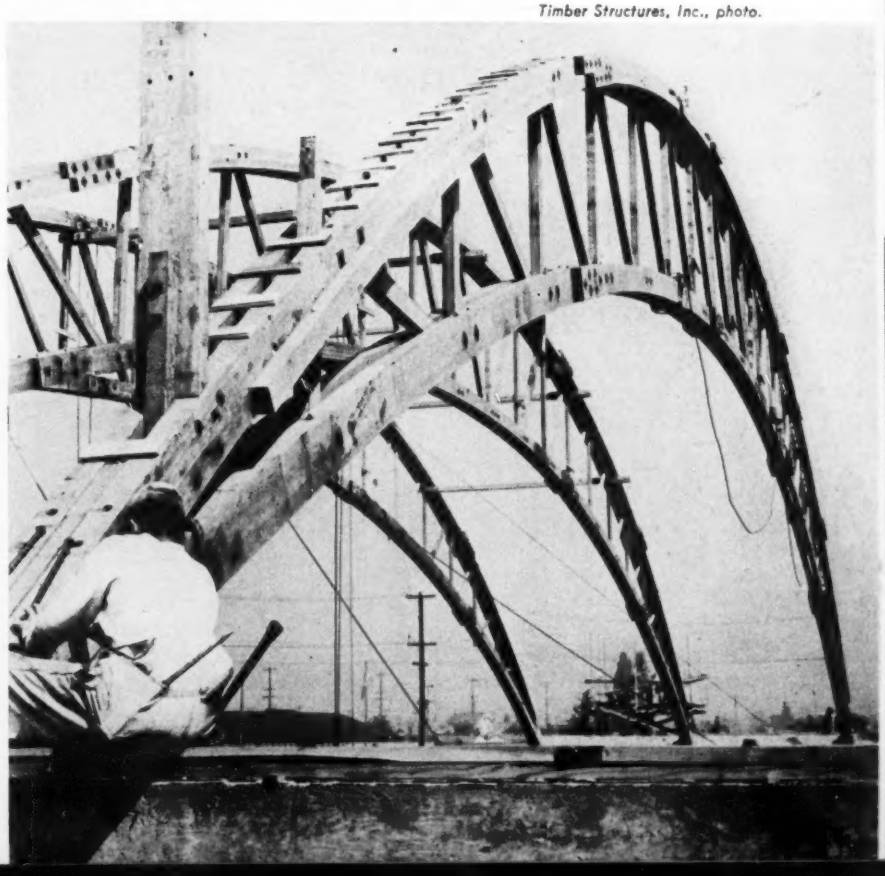
Increased costs per board foot of laminated members must be overcome by careful design to take advantage of the following factors:

Increased Allowable Stresses—Bending, perpendicular compression and shear stresses are the same as for solid members, but allowable compression parallel to the grain is increased by 50 per cent because thin boards and plank for laminating are easily dried and are limited to less than 15 per cent moisture content for good gluing. The modulus of elasticity is generally rated at 10 to 15 per cent higher because dry laminated timbers are stiffer than green.

Position Selection (*members sub-*

Fig. 2. Heavy top and bottom chords of long-span wood trusses for wartime hangars were glued laminated timbers, substituting for solid members, which were unavailable at the time of construction.

Timber Structures, Inc., photo.



jected to bending)—Either all-dense or all non-dense material is used in one member, but the laminae are selected for position according to one of two procedures:

1. The outer two-fifths are the stress grade used in the design, but the inner three-fifths are one grade lower.

2. All laminae are the same stress grade but the outer two-tenths are selected to have knots not greater than one-half the maximum size permitted in that grade. The values for the next higher stress grade are employed in design.

Shape—Full advantage is taken of curved members, such as arches, whenever possible, and member are tapered to correspond to tapered stresses.

Hardware Reduction—For example, laminated chords of bowstring trusses eliminate numerous splice plates, particularly in the top chord, and increase the stiffness of the truss. Laminated arches require connections only at the ends of arch sections.

Maintenance Reduction—Shrinkage in framed solid timber structures requires servicing to tighten the structure. Laminated members, dry to begin with, require little servicing.

Built-up beams utilizing plywood webs and solid or laminated flanges have been employed in increasing numbers. Design in general conforms to the precedures for metal girders, either I or box cross-sections (Fig. 5), but important departures are made necessary by the characteristics of wood:

Fig. 3. Split rings, which in recent years have become standard practice for timber connections, are installed in grooves in the members and carry the load being transferred, while the bolts merely serve to hold parts together.

Different compressive and flexural strengths of wood require form factors to be introduced into the usual flexural formulas to modify the allowable stress in the compression flange in accordance with the ratio of the flange thickness to the total height. Design stresses in the tension flange are equal to the allowable flexural stresses.

The usual design stresses and moduli of elasticity include factors of nine-tenths to allow for customary depths and for shear deflections in ordinary beams. For girder design, flexural stresses and moduli of elasticity are increased one-ninth.

Shear deflection of wood girders must be taken into consideration, because of the low modulus of rigidity of wood. Horizontal shear in the webs must be computed by formulas involving the statical moment about the neutral axis. It is not safe to assume that shear is uniformly distributed throughout the depth of the webs.

The direction of the grain on both sides of glued joints requires careful consideration. If both are parallel to the direction of stress, relatively high stresses are allowable. If the grain is crossed or if both sides are perpendicular to the direction of stress, "rolling" shear develops and considerably lower allowable stresses must be employed.

The same general precautions respecting lateral stability must be employed as for metal beams.

Stiffeners are required primarily to stabilize the web against buckling and shear and to support the flanges under heavy loads, and their spacing is affected by the orientation of the grain in the face plies with respect to the axis of the beam. Because of the relative large thickness of the webs, stiffeners are usually rather widely spaced.

Joints and splices are best made by scarf-gluing, with a 12 to 1 slope of scarf generally satisfactory for both plywood and lumber. If scarfing is

Timber Structures, Inc., photo.

Fig. 4. Dredge spud, 30 in. square and 85 ft. long, constructed of glued laminated lumber. Wartime shortages of large solid timbers spurred the use of laminated construction.

not always feasible, splice plates must be employed with the precaution that rolling shear be avoided if possible.

Composite beams have been successfully made by nailing alone, by nail-gluing, and by shop gluing. The latter is to be preferred whenever feasible.

Many new glues developed

In many of the new techniques, glues play an important part. Originally, casein glue was almost exclusively employed because it can set and bond wood at temperatures down to freezing and, when properly fortified, possesses good durability under ordinary atmospheric conditions. Within the past ten years, however, synthetic glues have come to the forefront. They fall into the following classes:

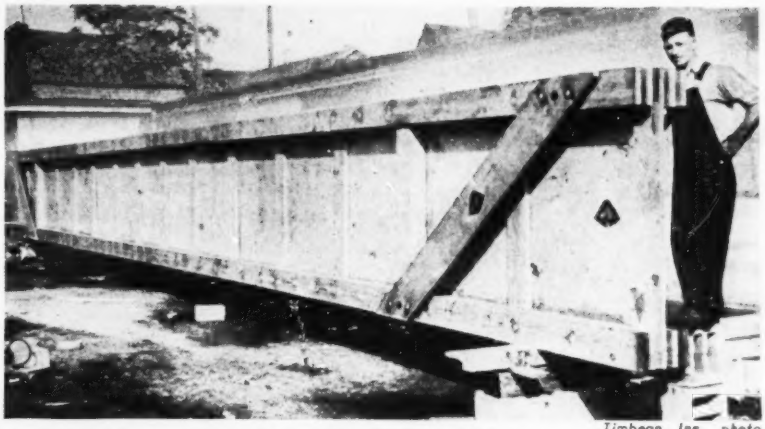
Urea-formaldehyde—These can be made to set at temperatures ranging from 70 to 300 deg. F. They possess excellent resistance to dry heat and to water up to approximately 130 deg. F., but may deterioriate rapidly in warmer water or humid atmosphere at approximately 160 deg. F., or higher.

Melamine-formaldehyde—These are the same general family as the ureas, but are hot-setting. They are boil-resistant and possess high durability.

Phenol - formaldehyde — The "straight-phenolic" resin glues are hot-setting. They possess superior resistance to boiling and to any condition of exposure—in water and out, above or below ground—and are proof against fungus or insect attack. Made in thin sheets for plywood manufacture, they are also used as liquid solutions for either plywood or general purpose gluing.

Phenol-resorcinal—By substituting resorcinal for phenol, the setting temperatures can be reduced to as low as 70 deg. F. High resorcinal content glues are expensive but are easily handled and are usable at low clamping pressures. They possess the same high boil resistance as the straight phenolics.

Glue lines are assumed to be as strong as the wood itself. Experience substantiates this assumption when glue bonds are properly made with adequate clamping facilities under shop-controlled conditions. Nail-gluing is rapidly being outlawed in important glue joints carrying heavy stresses.



Timbean, Inc., photo.

Fig. 5. Plywood webs and lumber flanges and stiffeners are combined to form a composite beam. Unit stresses in these girders are computed with the usual flexural formulas modified by a form factor.

Because of the economies attendant upon increased useful life and because of the high degree of fire-resistance possible in properly treated wood, the practice of treating timber came into increasing use during the war and may find still greater employment in structures intended for permanent occupancy.

Generally speaking, when treatment is carried out properly with either oily or water-soluble preservatives, no diminution of strength occurs because of the chemicals themselves. With some species of wood, however, it is necessary to incise the surfaces rather deeply at frequent intervals to obtain appreciable penetration of preservative, and the incisions may decrease the strength approximately ten per cent, according to such tests as have been conducted. (See *ENR* Nov. 15, 1945).

Tests carried out on phenolic-resin glued laminated timbers pressure-creosoted after laminating have revealed no weakening of the glue line. Salt-treated lumber has been glued without difficulty, and research is being carried on to determine whether creosoted material can similarly be glued.

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How and When to Use Aluminum Alloys

R. L. Moore
Research Structural Engineer, Aluminum Research Laboratories
New Kensington, Pa.

***Contents in Brief**—Light weight, combined with high strength, pleasing appearance, corrosion resistance, and availability in a wide variety of forms are properties that should make aluminum alloys attractive to structural engineers of the postwar period. Efficient design requires a knowledge not only of the mechanical properties of the various alloys, but also of the behavior of the basic types of structural members. Correlations of theory with experiments have led to the formulation of rules to assist in design.*

No STRUCTURAL MATERIAL is best suited for all purposes. To achieve a maximum of economy, materials must be selected and proportioned so as to fulfill efficiently the requirements of the owner of the structure. For this reason it is important that engineers be able to recognize and use wisely the distinguishing qualities of the newer materials.

However, mere recognition of desirable characteristics is insufficient for general adoption of a new structural material. These properties must be proved through actual in-service tests to be tangible, design data must be readily available, and the material must be easily obtainable in convenient structural shapes. The following analysis of aluminum alloys with respect to these criteria indicates that factors exist conducive to the acceptance of aluminum for more general engineering applications.

The combination of light weight with high strength makes aluminum alloys particularly attractive to the structural engineer. Although weights vary slightly with composition, most aluminum alloys weigh about 170 lb. per cu. ft. or 35 percent as much as steel. Mechanical properties, however, vary widely with composition, form, method of fabrication, amount of cold work or strain hardening, and heat treatment.

For example, according to Table I, which lists typical properties of some commonly used alloys, tensile

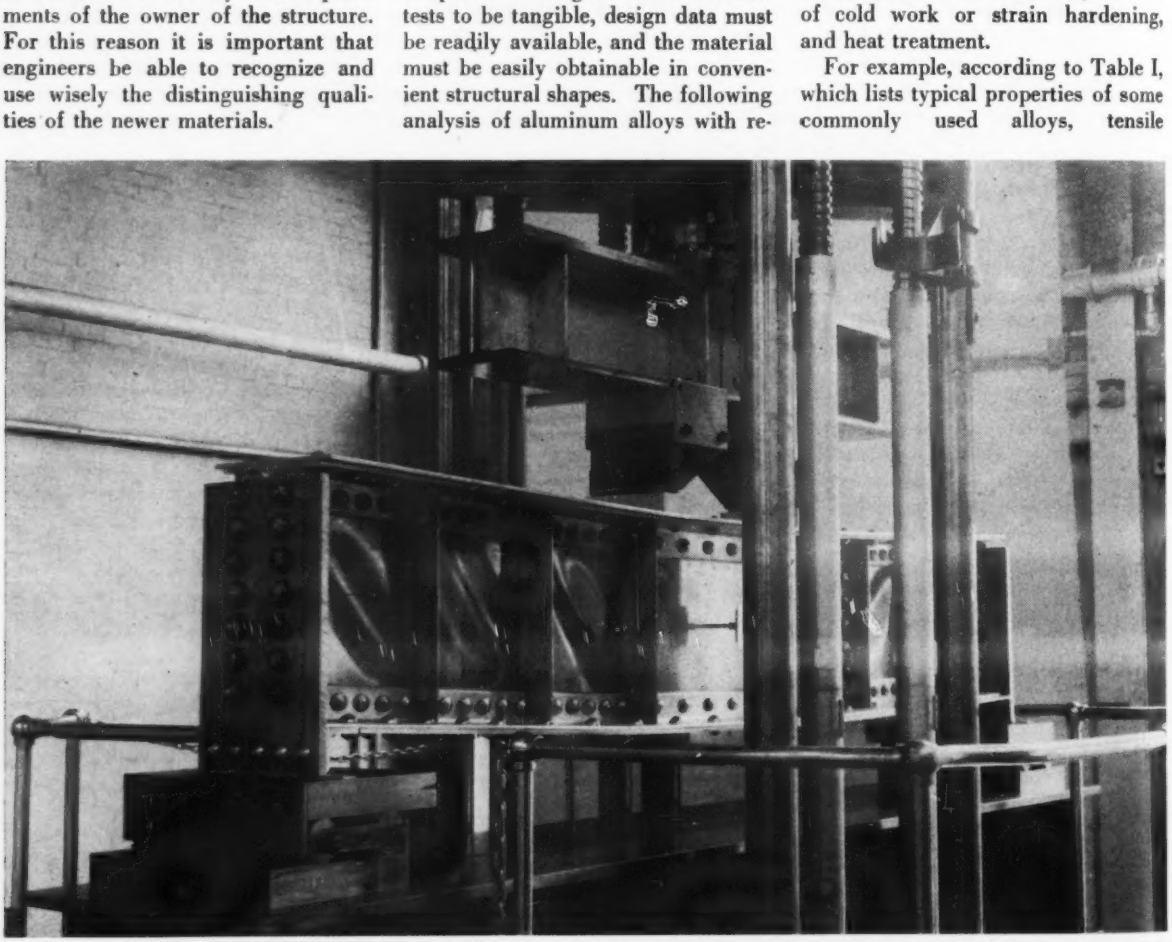


Fig. 1. Aluminum alloy girder 18 in. deep and of 9-ft. span with a 3/16 in. web under a load of 150,000 lb. The girder ultimately carried a load of 170,000 lb.

strengths may range from values as low as 12,000 to 16,000 psi. for non-heat-treatable, easily-formed alloys, to 85,000 to 90,000 psi. for the highest strength alloys currently used in aircraft.

Many examples of the structural use of aluminum alloys may be cited, ranging from light-weight bridge floors and emergency closure gates for dams to pontoon bridges and aircraft landing mats. Some 45,000,000 lb. of aluminum have gone into landing mats alone.

Appearance is important

From the standpoint of the architect and builder, the properties of light weight, combined with pleasing appearance and non-staining qualities, may be of principal interest. Specified for decorative purposes, millions of pounds of aluminum have given years of satisfactory service in window frames, stairs, doors, railings, ornamental grills and exterior wall spandrels for buildings. Experience gained in this field provides a valuable backlog of information on which to base the selection of aluminum for future uses of this nature.

For the engineer concerned with the design of structures and equipment exposed to many types of chemical action, the generally good corrosion resistance of aluminum is its outstanding property. Numerous applications of this metal have been made in sewage treatment works and in railroad roundhouses and in covers for large petroleum storage tanks. Also, its light weight, combined with strength and corrosion resistance, has made it particularly well suited for use in tank cars and containers for special products.

Available types and shapes

Any prospective new user of aluminum will, of course, be concerned with the forms in which the metal may be obtained. Table II lists those commonly available and provides information on the chief characteristics and uses of the different alloys.

Flat sheet and plate may be obtained in thicknesses ranging from 0.006 in. to 3.00 in., in a wide range of sizes. Rolled structural shapes in the form of angles up to 6 in. and channels up to 12 in. may be obtained in lengths of as much as 85 ft. in some sizes. Thousands of dies are available for extruded shapes, or new dies may readily be made to suit a customer's special needs. Either closed or open sections may be extruded, and in some cases sections may be varied along the length to obtain a more efficient distribution of material. Cross-sectional areas of high-strength extrusions may be as

TABLE I — TYPICAL PROPERTIES OF SOME WROUGHT AND SAND-CAST ALCOA ALUMINUM ALLOYS

Alcoa alloy No.	Temper	Tensile & compressive yield strengths,† psi.	Tensile ultimate strength, psi.	Elong. in 2 in., percent	Shear yield strength,† psi.	Shear ultimate strength, psi.	Fatigue endurance limit,* psi.	Brinell hardness (500 kg. load, 10mm. ball)	Weight, lb./cu.in.
3S-O	Annealed	6,000	16,000	40	4,000	11,000	7,000	28	0.099
3S-H	Hard	25,000	29,000	10	14,000	16,000	10,000	55	0.099
52S-O	Annealed	14,000	29,000	30	9,000	18,000	17,000	45	0.096
52-H	Hard	36,000	41,000	8	20,000	24,000	19,000	85	0.096
53S-T	H.T. & Aged	33,000	39,000	20	20,000	24,000	13,000	80	0.097
61S-W	H.T.	21,000	35,000	25	14,000	24,000	13,500	65	0.098
61S-T	H.T. & Aged	39,000	45,000	15	26,000	30,000	13,500	95	0.098
17S-T	H.T. & Aged	37,000	60,000	22	22,000	36,000	18,000	105	0.101
24S-T	H.T. & Aged	46,000	68,000	22	28,000	41,000	18,000	120	0.100
14S-W	H.T.	40,000	56,000	25	24,000	34,000	18,000	100	0.101
14S-T	H.T. & Aged	58,000	68,000	13	36,000	42,000	18,000	135	0.101
75S-T††	H.T. & Aged	80,000	88,000	10	42,000	47,000	22,500	150	0.101
195-T4	H.T. (casting)	16,000	32,000	8.5	10,000	24,000	6,000	60	0.100
195-T6	H.T. & Aged	24,000	36,000	5.0	14,000	30,000	6,500	75	0.100
220-T4	H.T. (casting)	25,000	46,000	14.0	15,000	33,000	7,000	75	0.092
356-T6	H.T. & Aged (casting)	23,000	33,000	4.0	14,000	27,000	8,000	70	0.095

† Yield strengths correspond to set of 0.2 percent.
†† Extrusions only.
* Based on 500,000,000 cycles of reversed bending.

TABLE II — AVAILABLE FORMS, CHARACTERISTICS AND USES OF ALCOA ALUMINUM ALLOYS

Alcoa alloy No.	Forms Commonly Available: Sheet and plate	Wire	Rod and bar	Rolled shapes	Extruded shapes	Tubing and pipe	Rivets	Forgings	Alclad sheet and plate	Sand castings	Heat treatable alloy	Chief Characteristics	Typical Uses
3S	x				x							Workability, weldability, resistance to corrosion.	Sheet metal work, tanks, piping, chemical applications.
52S	x					x						Excellent resistance to corrosion, good workability moderate strength.	Sheet metal work, marine and transportation applications.
53S		x	x	x	x		x	x			x	Excellent resistance to corrosion, good strength and workability.	Structures subject to severely corrosive conditions; naval, architectural and industrial applications.
61S	x	x	x	x	x	x					x	Good strength and workability, excellent resistance to corrosion.	Applications in shipbuilding and transportation fields.
17S		x	x	x	x		x	x			x	Relatively high strength with fair workability.	General structural use.
24S	x	x	x		x	x	x		x		x	Higher strength than Alcoa alloy 17S. Especially useful in form of Alclad sheet.	Most important structural material used in aircraft.
14S			x	x	x			x	x		x	High strength, limited workability.	Heavy-duty structural applications.
75S					x				x		x	Highest strength alloy.	Aircraft structures.
195										x	x	Good combination of strength and shock resistance.	General structural castings.
220										x	x	Highest strength and shock resistance. Resistance to corrosion.	Heavy-duty castings.
356										x	x	Weldability, pressure tightness, resistance to corrosion.	High-strength pressure-tight castings of intricate shape.

much as 10 to 15 sq. in., and maximum dimensions across the section as much as 16 in.

Wire, rods and bars may be obtained in diameters ranging from 0.005 in. to 8.0 in., and round tubing is available in diameters ranging from $\frac{1}{8}$ in. to 10 in. In addition to these forms, aluminum may be obtained as castings of either sand, permanent-mold, or pressure type; hammer or press forgings; impact extrusions; and screw machine products of various types.

Framing joints and connections

Aluminum members may be joined by riveting, welding or brazing. In aircraft, relatively small aluminum rivets of several alloys are used and all are driven cold, giving typical ultimate shear strengths ranging from 33,000 to 42,000 psi. Although pneumatic hand riveters may be used for small sizes of aluminum rivets, squeeze riveters are generally required for the larger sizes. In view of the pressures required to drive the strongest alloys in the larger sizes, hot steel rivets have been used in many of the large structural applications of aluminum. Care must be taken not to overheat the aluminum when this method of fabrication is utilized, and random riveting is used as far as practical to keep temperature rises at a minimum.

Welding may be done by oxyacetylene or oxyhydrogen torch; metallic or carbon arc; or spot, seam, or flash-butt resistance methods. In most aluminum tank construction, welding has become standard procedure. It should be recognized, though, that the welding of heat-treatable alloys results in a partial anneal and loss of strength and ductility in the immediate vicinity of the weld, just as in the case of heat-treatable steels. Beneficial effects from heat treatment after welding may be possible in some cases. In other cases the loss of strength in welded areas may be negligible. For example, the pontoon bridge balk shown in Fig. 3 (right) were not heat treated after welding, but the location of the welds on the neutral axes of these members minimized the effect of heat of welding on bending strengths.

Another effective and economical method of joining aluminum members in many cases is brazing. It may be done either in a furnace or by torch, using a filler material having a slightly lower melting point than the base metal.

Surface finishes

New users of aluminum alloys are also concerned with maintenance. In this connection it should be pointed out that while these alloys have a high resistance to corrosion, most outdoor installations nevertheless should be painted. The practice of cleaning with a phosphoric acid type cleaner, priming with a zinc chromate primer, followed by one or two coats of aluminum paint, is a generally satisfactory procedure. It is particularly important that aluminum be painted where it is in contact with steel in order to prevent the electrolytic corrosion of aluminum that may occur in the presence of moisture.

Many other types of finish are available for aluminum, however. Mechanical finishes such as sandblasting, wire brushing, or polishing may be used to enhance appearance, or a variety of chemical or electrochemical finishes may be used, when desired, to increase resistance to wear or corrosion.

Light weight greatest attraction

Undoubtedly the characteristic of aluminum alloys of greatest appeal to the structural engineer is that of light weight combined with high strength. Typical stress-strain relations for several heat-treated aluminum alloys, along with similar curves for two structural steels and a magnesium alloy for comparison are shown in Fig. 4. Data of this type are of fundamental importance in that they form the basis for estimates of deflection, flexural stiffness, buckling resistance and permanent set. As indicated by the linear relations between load and strain shown, aluminum alloys have as definite an elastic range as the other materials considered.

Creep, or gradual elongation under sustained load, is not measurable within this stress range at ordinary temperatures in the alloys of structural importance. Specimens of duralumin type alloy 17S-T, for example, have been subjected to dead loads producing tensile stresses of 50,000 psi., or 85 percent of the breaking strength, for almost 20 yr. without appreciable changes in length.

Design proportions important

The moduli of elasticity of most of the aluminum alloys in tension and compression range from 10,000,000 to 10,600,000 psi. Moduli in shear are about 38 percent of those in tension. Although these values differ from those of other metals, materials should seldom be compared on the

Fig. 2. Landing mat installations at our airbases have absorbed a large tonnage of aluminum in a new type of application.

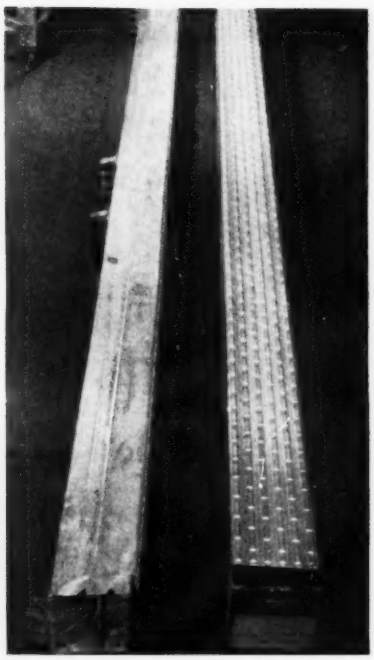


Fig. 3. A war-born structural use of aluminum is in this new pontoon bridge designed by the U. S. Engineers, in which both deck balks and pontoons are of the light weight metal. At the right is shown a close-up of the balk, which serves the dual function of wearing surface and stringer.

basis of relative moduli of elasticity alone. Shape of section and weight are equally important.

For instance, while the load required to produce elastic buckling in a flat plate of aluminum is only about one-third that required to produce the same action in a steel plate of the same thickness, the difference in buckling loads for plates of the same weight is 9 to 1 in favor of aluminum. In the design of aluminum alloy landing mats, a 40 percent increase in the thickness of aluminum over that used in steel has resulted in equal flexural stiffness with a 50 percent saving in weight. The 45,000,000 lb. of aluminum that have gone into landing mats to date emphasize the practical importance of the high stiffness-weight ratios obtainable with aluminum alloys.

Plastic yielding of most of the aluminum alloys occurs gradually as the stress exceeds the elastic limit. Hence, yield strengths are determined as the stresses at which the offset from the initial straight-line portion of the stress-strain diagram is 0.2 percent. This procedure of locating the yield point is similar to that used for many cast and special alloy steels for which the familiar "drop-of-beam" method is not applicable. The fact that there is no sharp knee or break in the stress-strain relation for aluminum alloys to indicate a definite point of yielding results in treating plastic buckling problems concerning aluminum somewhat differently from those involving structural steels, where a well-defined yield point usually limits quite definitely the maximum stresses that may be developed.

Ductility of alloys varies

As indicated in Table I, typical elongation values for the heat-treated wrought aluminum alloys range from about 10 to 25 percent. In the aircraft field the continuous demand for higher yield strength aluminum alloys has resulted in a gradual decrease in elongations. Minimum values as low as 6 percent are specified for 75S-T, the highest strength aluminum alloy in current use; yet this relatively low value, as judged by some standards, has not prevented the use of this material in the design of rugged and efficient aircraft structures.

Engineers are becoming increasingly cognizant of the fact that comparatively little is known regarding the minimum ductility requirements of a structural material. Some ductility is obviously required to permit forming operations and fabrication, to relieve stress concentrations and to provide toughness against shock loadings. Apparently, the amount considered necessary depends to a large extent upon one's viewpoint and previous experience.

Conclusion from column research

Determinations of column strength have probably constituted the most important single field of investigation into the behavior of aluminum alloy structures. Typical *ultimate* column strength curves for several alloys as shown in Fig. 5. The abscissa for the curves is equivalent slenderness ratios, KL/r, where L = column length, r = least radius of gyration of the section, and K = ratio of length of equivalent round or pin-ended column to the full length L. For a fixed-end column, $K = 0.5$; for a pin-ended column, $K = 1.0$. Values of K intermediate between those corresponding to fixed and pin ends are generally assumed in design.

Within the range of elastic action (large values of KL/r), strengths are determined by the well-known Euler formula, where modulus of elasticity and slenderness ratio are the governing factors. For stresses above the elastic range of the material, column strengths for most alloys vary about linearly with slenderness ratios, and formulas of the straight-line type are

widely used as a basis for design.

The maximum ordinates for the curves in Fig. 5 ($KL/r = 0$) are equal to the compressive yield strengths of the material multiplied by the empirical factor

$$\left(1+\frac{CYS}{200{,}000}\right)$$

where CYS is the compressive yield strength. From these maximum ordinates, straight lines are drawn to a point of tangency on the Euler curve to indicate the linear relations of stress and slenderness. The algebraic expression for any of these straight-line relations is readily obtainable if it is recognized that the ordinate to the point of tangency on the Euler curve is equal to one-third the ordinate for $KL/r = 0$. Column formulas of this type, expressing *ultimate* column strengths, are given in the *Alcoa Structural Aluminum Handbook* for all commercial wrought aluminum alloys.

Safety factor must be applied

In selecting allowable working stresses for aluminum alloy columns it is necessary to divide the ultimate strengths indicated by curves or formulas of the type shown in Fig. 5 by a suitable factor of safety. Such a factor of safety should be at least as conservative as that used in selecting basic design values in tension and compression. (A complete set of specifications for the design of bridges and structures of high-strength aluminum alloy was prepared in 1940 by the late Leon S. Moisseiff, consulting engineer.)

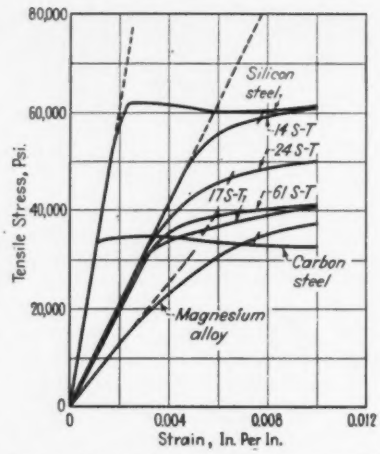


Fig. 4. Stress-strain curves for several metals indicates that curves for aluminum alloys differ from those for steel in that there is no sharp break that definitely locates the yield point.

Although most of the tests made to establish ultimate column strength curves for the aluminum alloys have been made on single-member struts, some investigations of built-up columns have also been made. Failure of a 9-ft. long column of 17S-T ($L/r = 40$) composed of two 7-in. channels joined by conventional lacing is shown in Fig. 6. The maximum load carried was 235,000 lb., corresponding to an average compressive stress of 32,600 psi., or a value approximately equal to the compressive yield strength of the material.

It is of interest to point out that a structural carbon steel column of nominally the same dimensions but having a higher yield point carried a maximum load of 273,000 lb. or only 16 percent more than the 17S-T column that weighed one-third as much. The proportions of these columns were such that the difference in the moduli of elasticity for steel and aluminum had no appreciable effect upon the column strengths.

Buckling in aluminum members

Although column action probably represents the most significant type of buckling encountered in structural design, questions of stability also arise in estimating the lateral buckling resistance of beams, the strength of flat plates under edge compression and the buckling resistance of girder webs. In order to obtain practical solutions for plastic buckling problems of this kind it has been found convenient to express the controlling dimensions of the plate or flange in terms of equivalent slenderness ratios (KL/r) and to substitute these values directly in the column formula for the alloy in question. This procedure is based on the assumption that the influence of plastic action upon the buckling resistance of columns is representative also of the effect of plastic action upon buckling of other types of elements. Some experimental data supporting this assumption have been obtained.

Equivalent slenderness ratios for plates under edge compression may be determined from the following derived relations:

Case I. For plates simply supported along both edges parallel to the direction of loading, $KL/r = 1.65\ b/t$, where b = plate width and t = thickness.

Case II. Same as Case I, but for fixed edges, $KL/r = 1.25\ b/t$.

Case III. For plates simply supported along one edge parallel to the direction of loading and free on the other edge, $KL/r = 5.1\ b/t$.

Case IV. Same as Case III but for one edge fixed, $KL/r = 2.9\ b/t$.

It is quite evident that the degree of edge restraint assumed has an appreciable effect upon values of KL/r, but general rules for the selection of edge restraining effects obviously

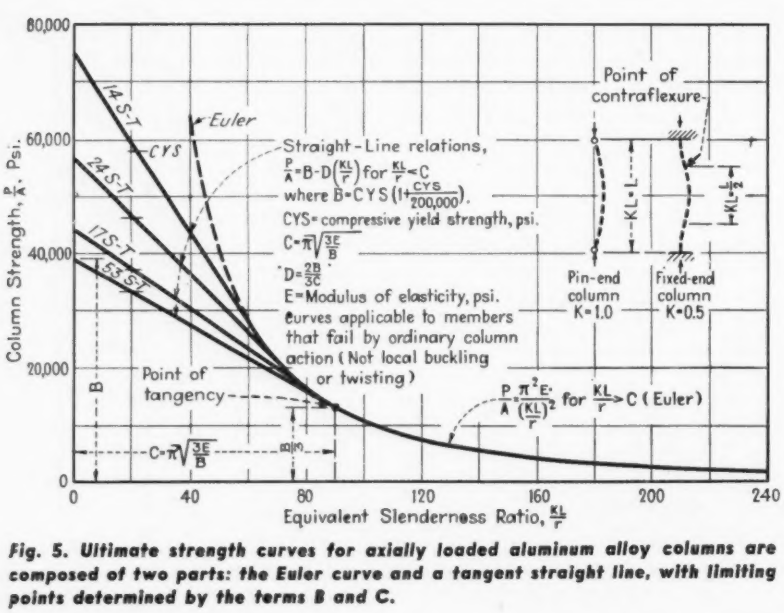


Fig. 5. Ultimate strength curves for axially loaded aluminum alloy columns are composed of two parts: the Euler curve and a tangent straight line, with limiting points determined by the terms B and C.

cannot be given. In most cases they probably should be taken intermediate between fixed and simply supported edges.

The selection of factors of safety against plastic buckling of this type depends upon the function of the element in question. If buckling results in only local or partial failure, higher working stresses should be allowed than if buckling means total failure.

Lateral buckling in flanges

The resistance of a beam or girder flange to lateral buckling presents a more complicated problem than that for plates, in that the torsional stiffness of the entire section, as well as the lateral bending stiffness of the compression flange, is involved. The same approach to the buckling problem in the plastic stress range has been used, however, and the equivalent radius of gyration, r, of such a flange may be determined from the relation

$$r = \sqrt{\frac{0.2}{S_c}\sqrt{I_1\left[J\,(KL)^2 + 13.1\,I_F d^2\right]}},$$

where S_c = section modulus for beam about axis normal to web (compression side), in.^{3}; I_1 = moment of inertia for beam about principal axis parallel to web, in.^{4}; L = laterally unsupported length of compression flange, in.; K = factor representing end conditions of laterally unsupported length, same as for columns; I_F = moment of inertia of compression flange of beam about axis parallel to web (may be assumed equal to $\frac{1}{2}$ of I_1 in the case of I-shaped members having both flanges alike), in.^{4}; d = depth of beam, in.; and J = torsion factor, in.^{4}

Values of J for structural shapes are given in the *Structural Aluminum Handbook* or they may be computed from formulas given in standard texts on mechanics of materials. For open sections composed of rectangular areas, $J = \Sigma\ 1/3bt^3$, where b = length of each rectangle and t = thickness.

In making use of the above expression for r in the column formulas, it is again necessary to select a value of K representing the end conditions of the laterally unsupported length of flange. As in the cases of flat plates under edge compression, some judgment is needed in the selection of this factor. Values of $K = 0.5$ and $K = 1.0$ represent the limiting cases of fixed- and simply-supported ends, respectively. The *Structural Aluminum Handbook* gives, in table form, value of KL/r for commercially available sizes of I-beams, H-beams and channels for a wide range of spans. Here again, suitbale factors of safety must be selected for design.

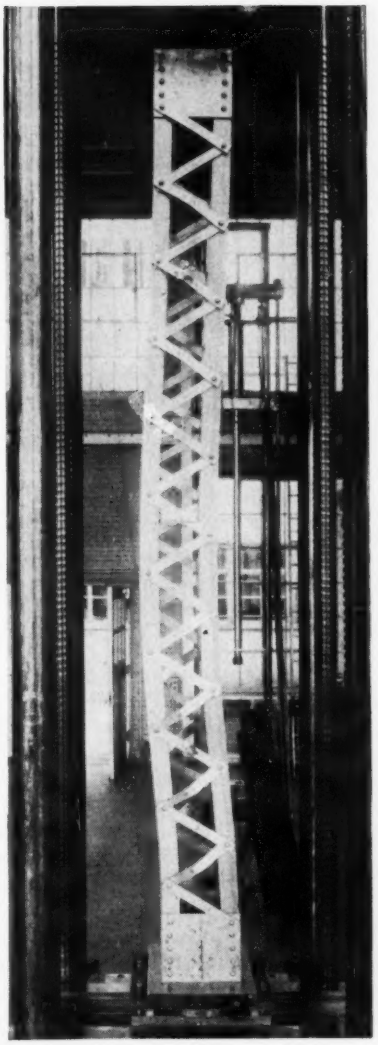


Fig. 6. Aluminum alloy column sustained a load almost equal to that of similar structural steel column.

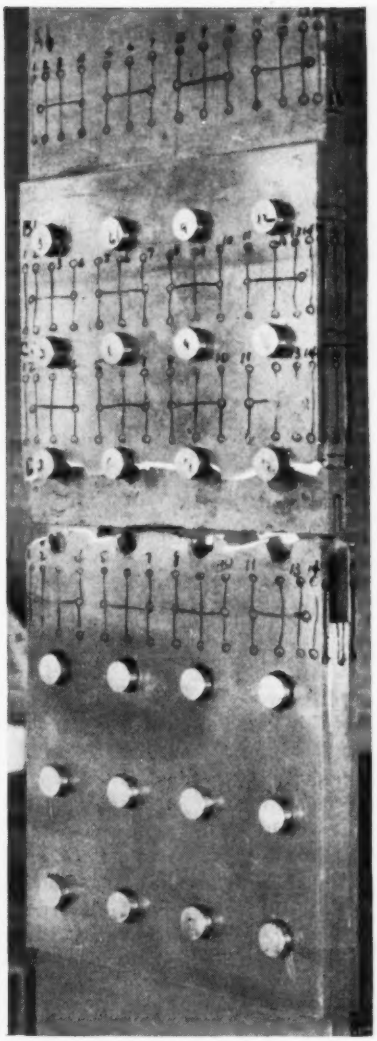


Fig. 7. Joint of aluminum alloy failed in tension at stress of about 62,000 psi. on net section.

Shear buckling in plates

The problem of shear buckling in aluminum alloy flat plates has been treated somewhat differently, in that the theory of elastic action has been considered applicable up to a limiting stress value equal to the yield strength of the material in shear (see Table I). The following formula is used for computing critical shear values for plates having simply-supported edges; corresponding values for fixed edges are approximately 65 percent higher.

$$s = \frac{51{,}000{,}000}{(b/t)^2}\left[1 + 0.75\,(b/a)^2\right],$$

where s = critical shear stress, psi.; b = short dimension, in.; a = long dimension, in.; and t = thickness, in.

Numerous tests have been made in connection with studies of shear-buckling phenomena in aluminum alloy girder webs. For example, Fig. 1 shows a 17S-T girder with an 18-in. deep by 108-in. long by $\frac{3}{16}$-in. thick web that developed an average shear stress on the gross area of 20,000 psi. before appreciable web buckling occurred. This girder ultimately carried a load of 170,000 lb., equivalent

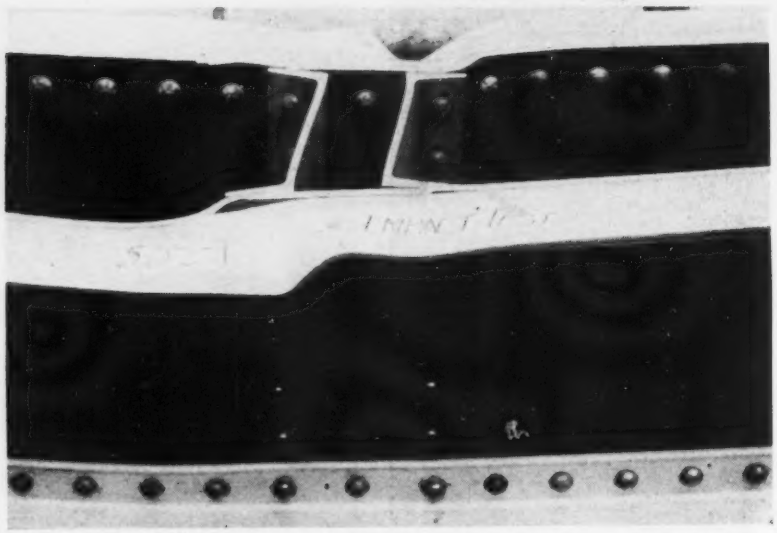


Fig. 8. Resistance of aluminum alloys to shock is indicated by condition of an alloy 53S-T double-web girder after impact test made by dropping a 2,000-lb. tup at the center of a 10-ft. span from heights ranging up to 52 in.

to an average shear of about 25,000 psi.

This test is of particular interest in that the specimen proportions were quite similar to those of a steel girder tested a number of years ago at the University of Illinois (*Experiment Station Bulletin* No. 86, 1916). The steel girder, which weighed about 850 lb., failed by web buckling at a load of 220,800 lb., or a value only 30 percent greater than the load carried by the aluminum girder weighing 295 lb. The strength-weight ratios for the two girders were on the order of approximately 2 to 1 in favor of aluminum.

Recommended stiffener spacing

In any attempt at rational design of light-weight girder webs, consideration must be given to the spacing and proportions of intermediate stiffeners. The following empirical formula has been proposed as a tentative basis for the design of stiffeners on shear-resistant aluminum alloy webs:

$$I = \frac{1.31\,(dt)^2}{b^2},$$

where I = moment of inertia of stiffener, in.^{4}; d = clear depth of web, in.; b = stiffener spacing, in.; and t = web thickness, in.

Although experimental investigations of stability under compressive, shear, or bending loads have constituted a large part of the fundamental research done on structural aluminum, many other types of action have also been studied. For example, Fig. 7 shows a tensile fracture of a large riveted joint of aluminum alloy 17S-T, composed of $\frac{3}{4}$-in. by 12$\frac{1}{2}$-in. main plates joined by $\frac{3}{8}$-in. thick splice plates. Failure occurred under a load of 418,000 lb., corresponding to an average tensile stress on the net section of 62,000 psi. This stress value was within 2 percent of the tensile strength of the plate material.

A structural carbon steel joint of nominally the same dimensions, weighing approximately three times as much, carried only 4 percent more load at failure. Tests of this kind have demonstrated that in many respects conventional design procedures for steel are equally applicable to structural aluminum.

The structural tests cited above are only a few examples of the experimental work done at Aluminum Research Laboratories during the past 15 to 20 yr. Some tests have come under the heading of fundamental research, whereas others have had to do with the behavior of aluminum in particular structural applications. The objective underlying all such work has been to obtain a better understanding of some of the properties of aluminum and their relation to successful design and performance in engineering applications.

Although it is obviously not possible to predict closely what the future requirements for aluminum will be, there seems to be no question but that they will far surpass any previous peacetime demands. A number of reasons, aside from greater availability (U. S. production capacity is seven times what it was in 1939) and its possible effect upon price, may be advanced in support of this view.

First, and perhaps most significant, is the fact that aluminum is a comparative newcomer in the field of metallic materials. Its possibilities have only begun to be realized. Also alloys in current production today have yield strengths almost 100 percent greater than the highest available commercially 20 yr. ago, and maximum tensile breaking strengths have been increased as much as 50 percent. A continuation of such metallurgical developments will obviously have a pronounced effect upon future demands and uses for aluminum.

Other favorable factors are the increase in the number of engineers and fabricators who have acquired, since the beginning of the war, an intimate knowledge of the properties, uses and advantages of aluminum; and the fact that the general public has become increasingly aware of the advantages of light weight in many structural applications.

In so far as building construction is concerned, aluminum alloys have been used principally as a decorative material, and their structural application has been quite limited because of the unimportance generally of the weight saving advantages offered. The first structural use of aluminum in a building framework in this country was in the U. S. Botanic Garden Conservatory in Washington, D. C., where 33 tons of aluminum alloys were installed in the dome in order to eliminate rust stains and to reduce maintenance costs. Another special application of aluminum in building construction has been large emergency flood bulkheads, some of which are panels approximately 9 x 24 ft. weighing 1,400 lb., which were built for the windows and doors of a Pittsburgh department store. In this instance, light weight and ease of handling were governing factors. The use of structural aluminum in building construction will for some time, it is expected, be limited to such special applications, where appearance, resistance to corrosion, or ease of handling are considerations of primary importance.

Fig. 1. Floors, sidewalls and roof in North American Aviation Building, Grand Prairie, Tex., were 18-ga. steel panels.

Light-Gage Steel for Peacetime Building

Milton Male
Research Engineer, United States Steel Corp. of Delaware
Pittsburgh, Pa.

***Contents in Brief**—Four steps taken in recent years should give added impetus to the application of light-gage steel to the construction of many kinds of buildings. These undertakings have culminated in the establishment of a specification for the base metal and confirmation of the belief that the modern types of light steel construction, as commonly used with protective paint applied before erection, can meet all the usual requirements of service. Under preparation and almost completed are a specification for the design of structural elements of light-gage steel and a series of standard shapes.*

SPECTACULAR ADVANCES were made during the war in the use of light structural shapes, cold-formed from sheet or strip steel. They were employed in large aircraft plants, portable combat hangars, barracks and other permanent edifices for military personnel, civilian housing projects and task force buildings—structures ranging in size from plants with over 23 acres of roof surface to small, demountable prefabricated barracks that could be shipped to outlying military bases to be erected in less than 40 man-hr.

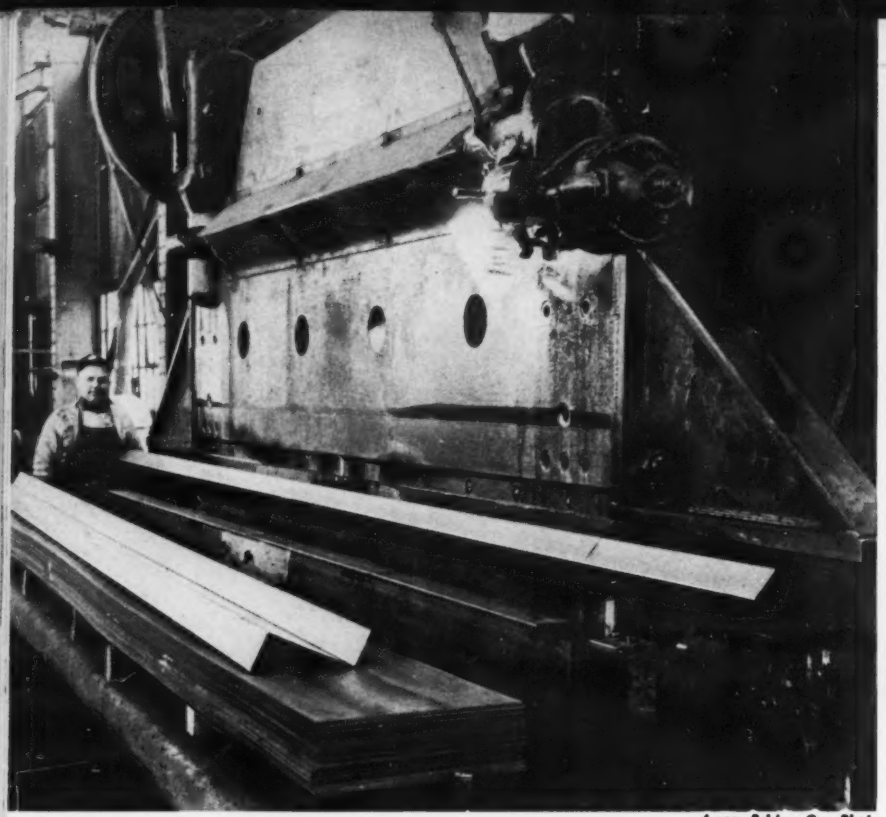
The experience accumulated during this period by designers, and especially by fabricators, will prove particularly valuable in peacetime, when cost and suitability are the criteria rather than the wartime practice of sacrificing economy to save time. In addition, establishment of standards for lightweight structural steel shapes and determination of their durability presages extensive developments in the application of light-gage steel to building construction.

Behind these recent applications lies a long record of satisfactory performance dating back to 1855, when $\frac{1}{16}$- and $\frac{1}{8}$-in. thick iron sheets were cold-formed and riveted together into I-beam shapes for use in the Bank of the State of New York Building. Although the general construction of the floor system violated nearly every principle of good design as we know it today, yet it performed the work required of it for nearly 50 yr. before the structure was demolished in 1903. (An interesting account of this structure is to be found in the September 10, 1903 issue of *Engineering News*, pp. 214-215.)

Light steel used in World War I

There was hardly any further advance in the art of light steel construction until about 1910, when it came to be employed more extensively. World War I saw standard prefabricated buildings used for warehouses, sheds, factory buildings and garages; and some of the manufacturers of those buildings are still engaged in that field today. In general, during this period light-gage members were used as secondary framing, or as floor or roof deck panels, supplementing the conventional hot-rolled structural shapes used for primary members.

In the decade beginning with 1930,



Amer. Bridge Co. Photo

Fig. 2. Press-brake shapes Z-purlins of 14-gage steel. Lips stiffen these sections and keep them straight after forming.

a great variety of systems were introduced, all utilizing light steel in one form or another. Developed for civilian use, these constructions were used primarily for residences and other buildings where loads and spans were moderate and where wood framing had been generally more economical than steel framing of the heavier types. Steel members offered the advantages of increased fire protection, greater strength and reduced maintenance cost. Furthermore, in the case of large-scale building operations, economy and speed in construction were achieved through standardization of structural units and through quantity production.

Light members ease assembly

One group of these modern systems of light steel construction (Fig. 3) consists of sections used individually or pre-assembled into large framing panels before erection at the site. The lightness of the members facilitates such assembly and cuts down field handling of a large number of small pieces, thus speeding up the work.

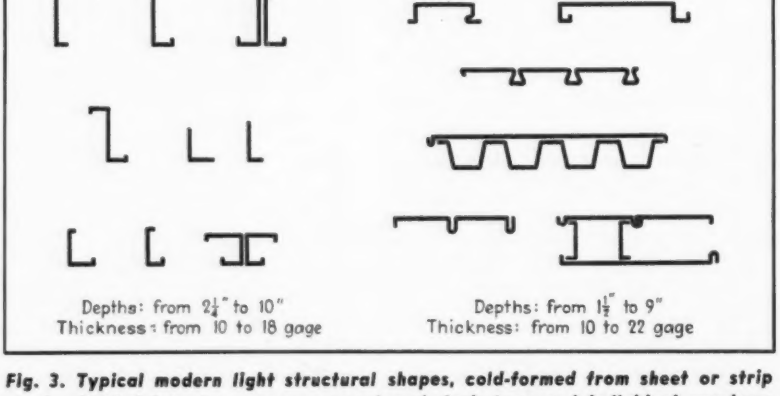

INDIVIDUAL FRAMING MEMBERS
PANEL AND DECK MEMBERS
Depths: from 2¼" to 10"
Thickness: from 10 to 18 gage
Depths: from 1½" to 9"
Thickness: from 10 to 22 gage

Fig. 3. Typical modern light structural shapes, cold-formed from sheet or strip steel,, divided into two groups—panel and deck type and individual members.

Members are installed at relatively close spacing—about 24 to 48 in. for floor and walls and 30 inches for roofs—primarily because the materials applied to them, such as insulating sheathing and roofing plank, require close spacing for support. Depending upon conditions, thicknesses range from 10 to 18 gage (about $\frac{1}{8}$ to $\frac{1}{18}$ in. thick).

Another prominent group, usually referred to as panel construction, has large surfaces integrally connected to the ribs or load carrying parts. The large sheet steel areas in this case also carry some load, but more important, function as the wall, floor, or ceiling surface. Steel roof deck, which has long been popular in the building industry, is a special type of panel construction, usually much shallower (about $1\frac{1}{2}$ in. deep) considerably lighter (18 to 22 ga.) than the other forms.

Presses or rolls used for shaping

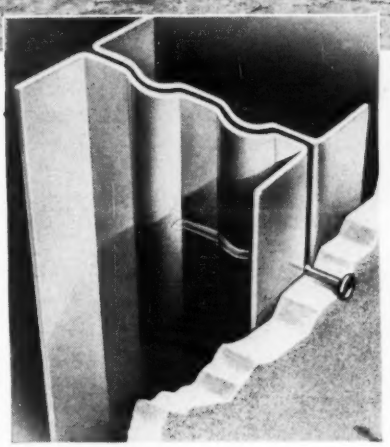
The relatively simple shop equipment required for the fabrication of light-gage members is available everywhere. Press-brakes ranging in certain cases up to 26 or 30 ft. in length, or cold rolling mills of the Yoder type, will handle all the forming work.

Producing sharper corners and closer dimensional tolerances with less springback than cold forming rolls, presses are preferred for panel construction where close fit-up is necessary. Rolls are admirably suited for structural members, such as beams or channels, and are often used for floor or roof deck panels where the tolerances are no closer than for ordinary structural work. Generally, the quantity of a given member to be produced will dictate the type of forming equipment; press-brakes are more flexible for small runs, whereas rolling mills require considerable footage to justify the higher cost of rolls and the expense involved in setting up and changing them.

Spot or seam welding machines are generally employed in the shop for thicknesses up to 10 ga. (0.1379 in.), as many as three such sheets being successfully welded together. Material thicker than this usually requires arc welding. Although welding predominates, there are many applications where it is still advantageous to use punched or drilled holes and rivets, bolts, or self-threading screws especially for field erection.

Stran-Steel photo

Fig. 4. Wall sections for Navy houses, Jacksonville, Fla., were placed by hand. These 16-ga. sections contain patented nailing grooves (right) for attaching wall material to steel framing.



Further advances in the use of lightweight steel are expected to stem from four recent developments, the results of projects under way since 1939: (1) A standard specification for the base metal; (2) data on durability of structural members as related to intended life of building; (3) a specification for design of structural elements formed from light-gage steel; and (4) a series of standard sections to be made available for general use.

An important requirement in the use of any engineering material is a well established knowledge of its properties. In the related field of heavy structural shapes, for example, one of the largest contributing factors to their universal acceptance and use has been the confidence engendered in them by their production to an American Society for Testing Materials standard. Designers can, with certainty, work to prescribed unit stresses based on definite minimum properties of the steel.

But prior to 1941, in the case of light-gage, flat-rolled steel, whose properties had not yet been standardized for structural purposes, expedients were the order of the day. Sometimes, the usual unit stress of 18,000 or 20,000 psi. was permitted if the material had properties corresponding to A.S.T.M. A-7. Where other steel was used that did not conform to that specification (and most did not), the allowable unit stress was required to be reduced in proportion to the yield strength.

In effect, this situation simply meant that an element of uncertainty was injected into the design of a structure; because until a designer knew the strength of the material to be used for the structural members, he could not know what unit stress to use. Actually, he either insisted on material conforming to A-7, or he set some inordinately low figure for strength that could be more than met by the softest material likely to be furnished. In the latter case, the competitive advantages of steel was often lost.

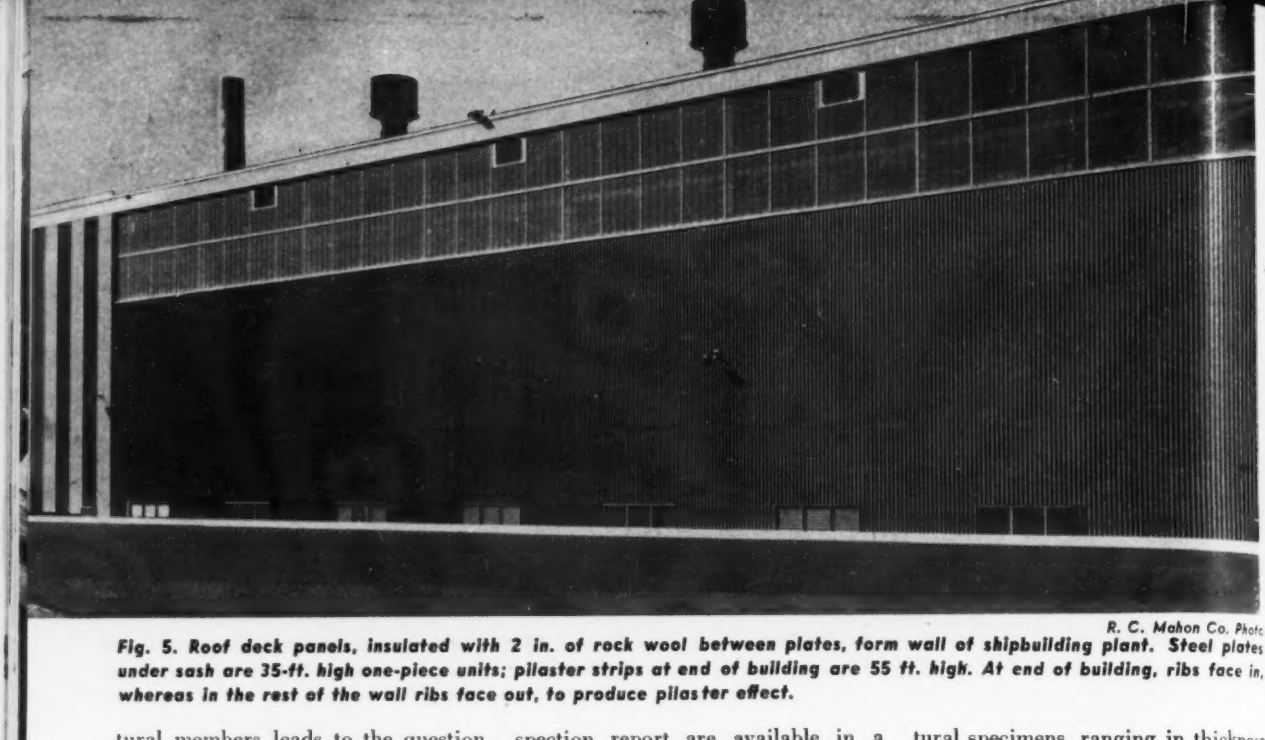
Standards for light steel approved

Hence, in 1941, there were issued two A.S.T.M. standards for the material—A245-T and A246-T—respectively covering thicknesses from about ¼ to 0.05 in. (this range covering the material principally used), and from 0.05 to 0.02 in. Each specification provides for three strength grades. Grade C has the same yield strength as structural steel, and two lower strength steels are intended for purposes such as non-load bearing partitions, library stacks and other similar applications, where strength requirements are less rigorous. The accompanying table shows the properties of Grade C steel as compared with structural steel.

Comparison of Properties of Light-Gage and Structural Steels

Materia	Yield strength min. (psi.)	Tensile strength min. (psi.)	Elongation in 2 in. percent
A-7 Structural Steel.....	33,000	60,000	22
A245–¼ to 0.05 in.....	33,000	55,000	22
A246–0.05 to 0.02 in....	33,000	52,000	18

It is interesting to note that in the early 1900's when structural steel was really getting into its stride, there were many reports in *Transactions of the American Society of Civil Engineers*, *Engineering News* and *Engineering Record* upon the condition of steel in various structures. One of the earliest such reports, in 1902, stated that "the increasing use of steel as struc-



R. C. Mahon Co. Photo

Fig. 5. Roof deck panels, insulated with 2 in. of rock wool between plates, form wall of shipbuilding plant. Steel plates under sash are 35-ft. high one-piece units; pilaster strips at end of building are 55 ft. high. At end of building, ribs face in, whereas in the rest of the wall ribs face out, to produce pilaster effect.

tural members leads to the question of its permanency". While such doubts as to the life of adequately protected heavy structural steel are today completely resolved, it may properly be asked whether there is similar evidence as to the durability of light-gage steel.

To answer that question, the American Iron and Steel Institute in 1940 engaged the Pittsburgh Testing Laboratory to survey the condition of painted light steel constructions in some of the older buildings. The laboratory selected 50 structures, well distributed geographically and of many different kinds. The average age was about 18 yr., the oldest having been in use for 35 yr. In many cases the light steel floor members had not been accessible for painting or other maintenance work since their installation, because they supported a concrete floor on top and a plaster ceiling below.

The report showed that the installations generally were in excellent condition and that the original paint coating still afforded effective protection to the steel members. The conclusions reached in the Pittsburgh Testing Laboratory's report, agreeing with the experience of others as reported from time to time in the technical press, indicate that the modern types of light steel construction, as commonly used with protective coating of paint applied before erection, can meet all the usual requirements of service. (Details of the inspection report are available in a bulletin issued in 1942 by the American Iron and Steel Institute entitled "The Durability of Lightweight Types of Steel Construction.")

Design standard proposed

Concurrently with the development of a material specification, work was progressing under the auspices of the Committee on Building Codes of the American Iron and Steel Institute on a specification for the design of light-gage steel structural members, since the existing specification of the American Institute of Steel Construction, applicable to heavy structural steel, could hardly be stretched to cover these lighter constructions for several reasons. Primarily, the present standard is applicable specifically for $\frac{1}{4}$-in. material and thicker, whereas the lighter types of steel construction often contemplate the use of material in the order of 14, 16 or 18 ga., or about $\frac{1}{16}$ in. thick. Secondly some of the special criteria applicable to thin members, such as buckling and elastic instability, are only infrequently encountered in the thicker and heavier structural shapes used for ordinary building construction. For the most part light-gage members have been designed on an empirical basis.

A research program was initiated by the committee at Cornell University to develop data on which to base a design specification. The testing program involved over 700 structural specimens, ranging in thickness from 0.1532 to 0.0245 in., and flange widths from 1 to 16 in. Structural members included formed beams, studs or light columns, and deck constructions.

Laboratory tests were paralleled and supplemented by extensive theoretical investigations of the strength and behavior of the members. This work, under way since early in 1939, has provided sufficient data to permit the presentation in the near future of a specification providing a sound, rational basis for the design of light-gage sheet and strip steel.

There are some aspects of the specification that are of general interest. One important consideration is that although the design procedures for light-gage structural members are superficially similar to those employed for the heavier hot-rolled sections, it is important to recognize certain limitations inherent in their use.

Since lightweight members are produced by forming the originally flat-rolled steel into various shapes and joining these together into structural sections (usually, but not always, by resistance welding), they are generally characterized by uniform thickness throughout each part. Therefore, in contrast to hot-rolled shapes, whose flanges are normally considerably thicker than the web, light-gage formed members usually have flanges of the same thickness as the web. In some cases, such as a pair of channels welded back-to-back to form an

I-section, the web is twice the thickness of the flange. Consequently, it is important to give consideration in the design procedure to the prevention of local instability or buckling of the compression flange. This feature is provided for by a distinction between the behavior of stiffened and unstiffened flanges, and their relative load-carrying capacities.

Other provisions worthy of note in the specification are:

1. The basic stress in bending is 18,000 psi. This is lower than the 20,000 allowed by the A.I.S.C. for heavy structural shapes, partly because of wider manufacturers' tolerance limits on the thickness of material, but primarily because the committee wished to keep the stresses at conservative values.

2. The use of higher strength steels at correspondingly increased unit stresses is permitted for those recognized grades whose minimum yield point and other properties are guaranteed by the manufacturer.

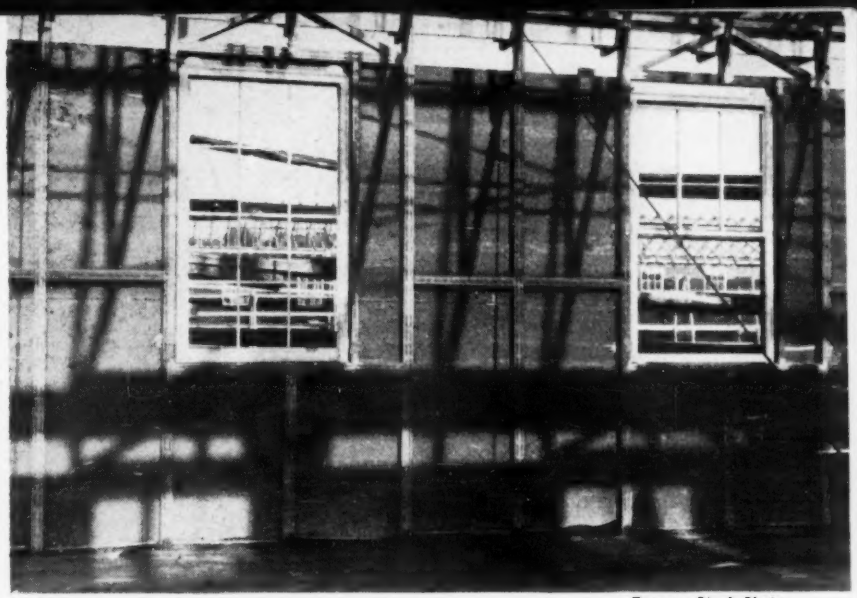
3. Two sets of allowable column stresses are given, based on considerations of end restraint, straightness of member and unavoidable eccentricity due to loading.

4. Stresses for beams with laterally unbraced compression flanges are given in terms of the ratio of length to radius of gyration, rather than to flange width. This is done because many members are provided with lips, and such a flange is inherently stiffer in resisting lateral distortion than flanges without such lips.

5. Maximum flat width ratios (ratio of width to thickness) are specified for various types of compression elements.

6. Cognizance is taken of the bracing effect of collateral wall sheeting material on the strength of steel sections, and provisions are included for evaluating the lateral restraint required from, and supplied by, these wall materials and their attachments.

The usefulness of such a specification to the building industry can hardly be over-estimated. For the first time it will be possible for engineers to design light-gage steel structures based on sound engineering principles rather than by rule of thumb. The standard will also be of great assistance to building code officials throughout the country, permitting them to check the safety of a design submitted for approval without the necessity of requiring a load test. All of this should ultimately make for greater economy in use.

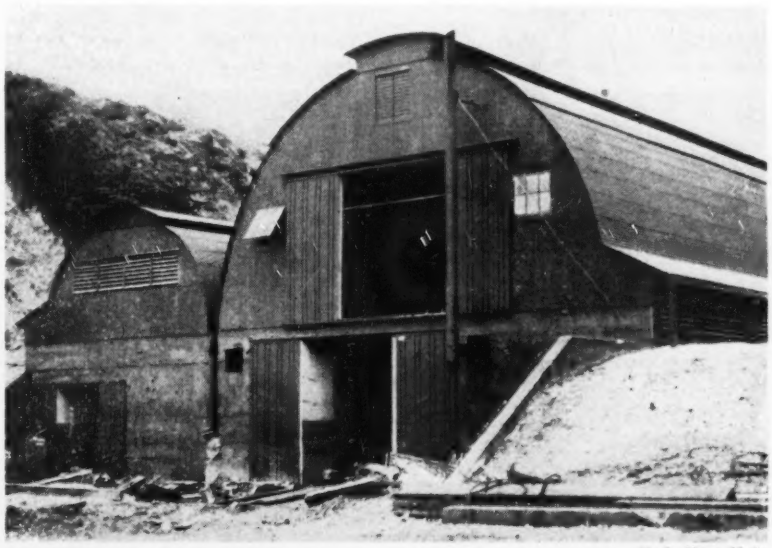


—Truscon Steel Photo

Fig. 6. In framing employed for Marine Corps Barracks at New River, N. C., individual steel members were assembled into large panels before erection. Nailing slots were used for wall sheathing.

Certain preliminary steps have also been taken to develop a series of shapes that would be acceptable as standard by fabricators and designers. Meeting informally under the auspices of the American Iron and Steel Institute, a technical group has been making a study of a series of shapes, consisting of channels, angles and zees, with and without lips, which alone, or in combination with each other, will provide sections sufficient for most purposes. It is expected that after the preliminary studies have been completed and reviewed by those concerned, the series will be made available by several companies.

The advantages of having a series of standard shapes with a sufficient range of depths, strength and weights are apparent. Any such series, if well chosen, would be welcomed by engineers and architects, and would greatly facilitate the widest possible application of cold-formed shapes. Historically, this was true in the case of hot-rolled structural shapes, and there is every reason to believe that a similar development will take place when standard cold-formed shapes are made available.



—U. S. Navy Photo

Fig. 7. After having seen extensive war services, Quonset huts are now available for civilian use, according to one of the manufacturers. Shown above is a bomb-proof power plant roofed by Quonsets, at the Naval Base at Guam.

Concrete Building Design Trend Shaped by Clear Space Needs

Arthur J. Boase
Manager, Structural Bureau, Portland Cement Association

***Contents in Brief**—Wartime experience with reinforced concrete in buildings has demonstrated the ingenuity of American engineers and the versatility of the material. Flat slab floors, rigid-frames and shell structures were developed to meet the demands for larger areas of clear space and for greater clear heights than had been provided hitherto, and mass production methods using traveling forms made possible the erection of buildings covering acres of space in remarkably short time.*

DEVELOPMENTS IN REINFORCED concrete have not come about overnight, with a revolutionary impact upon architecture and structural engineering. Over a period of time, these innovations are the result of evolutionary changes that depend to a great extent on the ingenuity and vision of designers of the period. Being evolutionary changes, they have a firm foundation and are, therefore, not likely to be transient. On the contrary, they are bound to have a far-reaching, lasting influence on the architectural and structural design of buildings.

During the last few years under the stimulus and necessities of war, American architects and engineers have applied the knowledge accumulated over nearly a century of reinforced concrete construction to the building of structures that only a few years ago would have been considered daring indeed in this country. And yet, in the sense that daring implies some risk, they have not been daring at all, for the design of these structures has been based upon proven engineering principles.

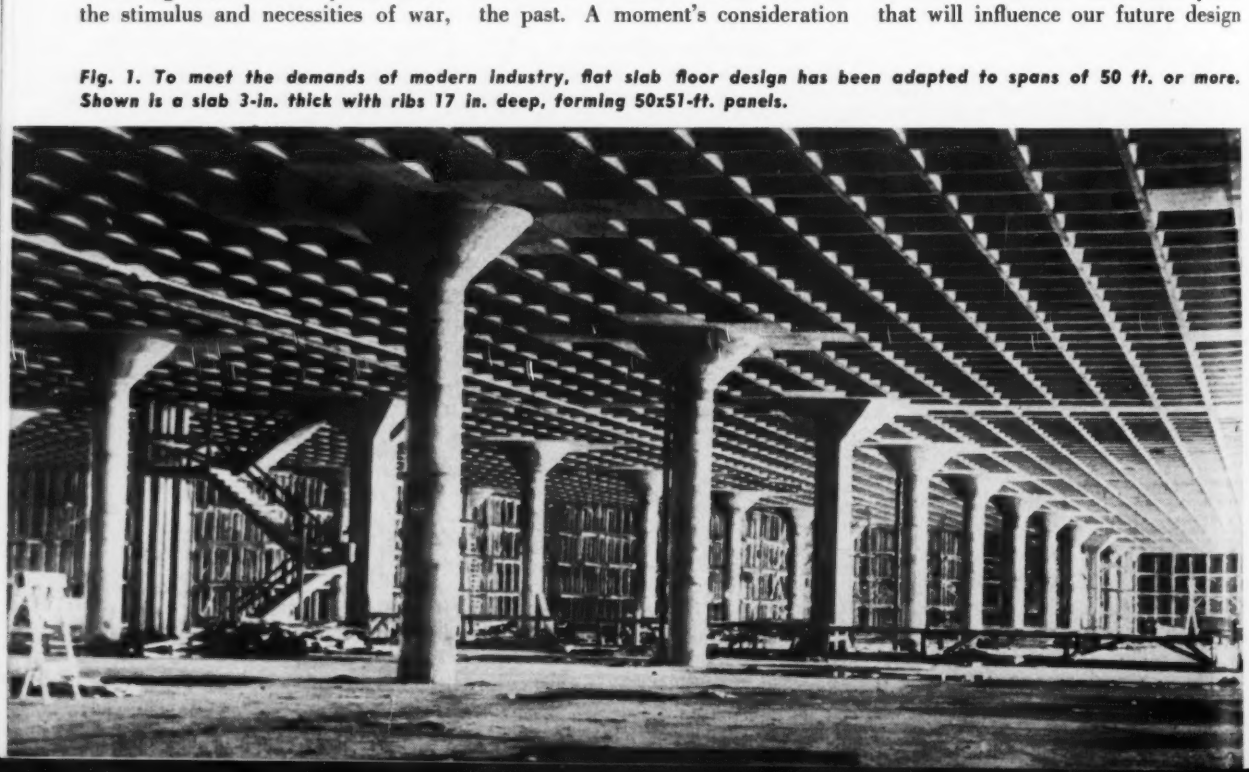
In the period which lies ahead these applications of reinforced concrete to modern building requirements will be as commonplace as 20-ft. span flat slab floor construction has been in the past. A moment's consideration of everyday practice in South America and in Europe before the war verifies the fact that what we have been doing recently, though new to us, has been long established abroad. It has been demonstrated to be of merit and, therefore, will endure.

Because of cost and of scarcity of other materials, foreign designers have long shown the way to designers in this country of the possibilities of reinforced concrete. Now, through force of necessity, we have found out by our own doing what can be done, and it is reasonable to assume that the resoursefulness of American architects and engineers will cause them to lead rather than follow their contemporaries in the other lands.

Need for clear floor space

Specifically, what have been some of these developments or, more properly, what have been some of the applications of reinforced concrete to unusual conditions in recent years that will influence our future design

Fig. 1. To meet the demands of modern industry, flat slab floor design has been adapted to spans of 50 ft. or more. Shown is a slab 3-in. thick with ribs 17 in. deep, forming 50x51-ft. panels.



practice? Industrial processes continually call for more and more clear floor space. It was only logical, therefore, that the engineer for an important manufacturer in the automobile industry, more recently engaged in the construction of bombers, should make use of the economy and load-carrying capacity of flat slab construction, even though the panels required were 50 x 51 ft.

To save weight, the floor was coffered as shown in Fig. 1, resulting in a ribbed slab 20 in. deep. The domes used to form the ribs were 17 in. deep, leaving a solid concrete top slab 3 in. thick. Tests showed deflections of less than 1/600 of the span under 1½ times the design load, which is not excessive, especially considering that the slab depth is only 1/30 of the span.

Subsequent performance has substantiated the sound judgment of the engineer in selecting this type of construction to meet the unusual requirements of the job.

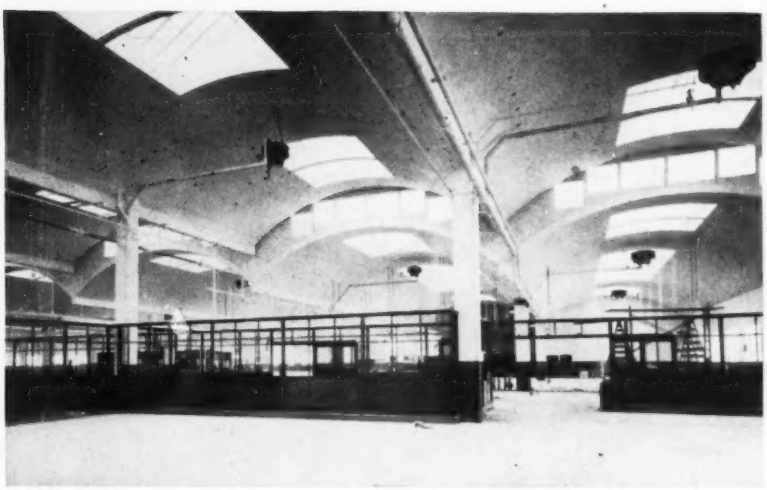


Fig. 2. No matter how extensive the shop, adequate light can be provided when reinforced concrete shell roof construction is used, because generous openings can be provided almost at will. Note the offset in the roof to provide additional ceiling height were needed. Edge members are generally used to reinforce free rims.

Flat slab design based on tests

The flat slab type of floor is an American invention. Its design has been based almost entirely on empirical moment coefficients, which have been determined by numerous tests of actual structures. Specifications and building codes have, therefore, placed many restrictions on the use of this type of floor except for very regular conditions. For instance, the ratio of length to width of panel may not exceed 1.33; the slab should be continuous for at least three panels in each direction; and the successive span lengths in each direction may differ by not more than 20 percent of the shorter span.

Since tests have not been made on structures with bays comparable to the previously mentioned bomber plant, one would hesitate to apply the empirical moment coefficients determined for much smaller structures. Fortunately, the *Building Regulations for Reinforced Concrete* of the American Concrete Institute, issued in 1941, gives a method of analysis covering any size of bay and with almost any irregularities.

The theory involved is merely the analysis of the structure as divided into a number of bents, each consisting of a row of columns and strips of supported slab of half bay widths on either side of the column. These strips are taken longitudinally and transversely, and total negative and positive moments can be determined in both directions by a number of well-known analytical methods. Once these total moments have been determined they can be apportioned between the column strip and the middle strip in proportion to the well-known arbitrary coefficients that have been in use for a number of years. For an appli-

Fig. 3. These 150-ft. dia. elliptical shell domes could just as well have been used to roof the rotunda of a fine bank, theatre or music hall as to cover the trickling filters of this sewage treatment plant.

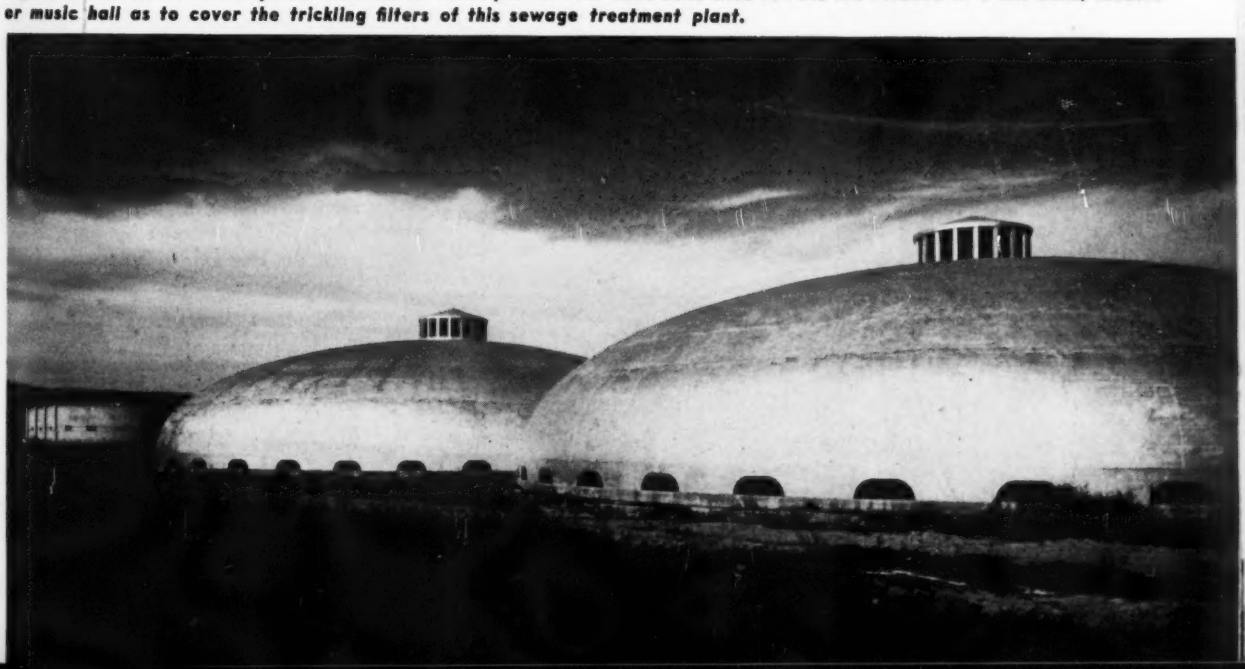


Fig. 4. Interior of a reinforced concrete, shell-roofed army warehouse, 182 ft. wide and 1,562 ft. long, that was built in 36 calendar days. This type of roof construction is especially well suited to use of traveling forms.

cation of this method see "Continuous Frame Analysis of Flat Slabs," by Professor Dean Peabody in the *Journal* of the Boston Society of Civil Engineers, July, 1939.

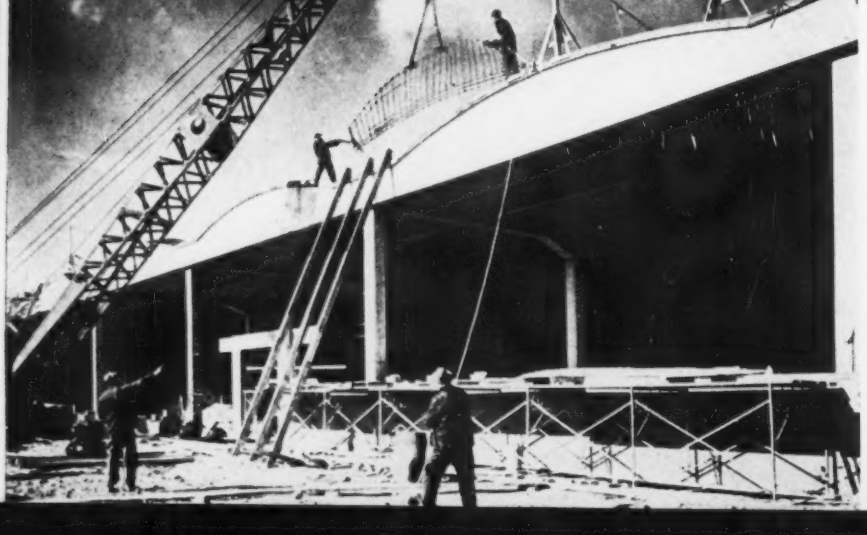
Thin shell structures new in U. S.

Prior to the war we saw the introduction of thin shell structures in this country, but owners and the building profession apparently doubted that 3- or 3½-in. thick reinforced concrete shells were adequate to span rectangular areas 60 ft. wide, or that domes 200 ft. in diameter or greater were entirely feasible. Such structures have been about as common as other types of construction in Europe, and practically every engineer in South America is familiar with the merits of shell structures from the standpoint of adaptability to unusual owner requirements.

In spite of what was an everyday occurence in other countries, it took a war to popularize shell roof structures here; but once having gotten the idea, U. S. engineers have built shell roofs at a greater rate than anywhere else in the world, and the total area today at least equals and may exceed that in any other country.

Thin shells or bent plates are used extensively as a natural protective covering because of their great resistance against exterior forces, a resistance that is primarily due to the fact that such shells are three-dimensional. For illustration, an egg shell has structural qualities that are extremely high compared with the thinness of the shell. The table tennis ball is another striking example of extreme lightness combined with great strength.

Fig. 5. Ingeniousness in the design of the traveling forms for this ribbed arch roof enabled the forms to be moved vertically and horizontally at a rapid rate.



Nature of shell stresses

The excellent structural qualities of three-dimensional plates or shells are explained by the fact that a load concentration is distributed over an imaginary circular plate elastically supported by adjacent portions of the shell. The span of this imaginary plate appears to be comparatively small and, as a consequence, the induced bending stresses are also small. Outside this region of local plate bending, the external force induces only direct stress in the shell structure, and direct stress can be transmitted economically through even a thin plate, especially when the plate possesses adequate curvature.

Another type of shell structure is one that can be developed from a plane membrane by rolling it around a cylinder and joining the free edges, thus creating a continuous cylindrical surface. Many counterparts of this type of structure are likewise employed in nature for development of great strength combined with extreme lightness, such as, for example, in the bamboo tree and in other reedlike plants.

Suppose that the plane membrane is attached integrally to parallel stiffeners or ribs, which together with the membrane are bent into the cylindrical shape. The ribs then become ring girders that support the pipe shell continuously around the surface, and with proper supports placed under the ring girders, the pipe shell can carry unusually large loads applied both longitudinally and transversely.

Shells strengthened at openings

The shells maintain some of their structural qualities even when they are cut so that only part of the sphere or part of the cylinder remains. However, the free rims or edges represent zones of structural weakness because direct stress can be transmitted only in the direction parallel to the rim or edge. In order to take full advantage of the structural qualities of the shell away from the boundary, it is necessary somehow to strengthen the free rim, and this may be done by adding a special edge member.

In an open spherical shell, a cir-

cular edge member designed for direct stress and some bending must generally be added along the boundary. Open cylindrical shells require stiffening members at the open ends and over the supports. Many types of shell structures are proposed for engineering uses, but most of them are modifications of the general principles briefly described.

Adaptability of shell construction

The versatility of this type of construction is shown by a few accompanying illustrations. In Fig. 2, note the freedom with which light openings may be provided, and where additional headroom is needed, the roof is simply stepped up the desired amount. The column spacing in this engineering shop of an army airfield is 40 x 54 ft. It might also be noted that in shell construction any combination of span widths is possible to accommodate space requirements without altering the fundamental form of the structure.

Where utility or purely architectural reasons indicate a dome roof to be the most desirable form, a thin shell of reinforced concrete meets the requirements. In Fig. 3, are shown two elliptical domes of 150-ft. diameter with a minimum shell thickness of 3½ in. These domes are the roofs of trickling filters of a sewage disposal plant, but the same architectural forms may just as well be used for a market hall, the rotunda of a library or for any one of a score of purposes.

Traveling forms speed construction

When Americans make up their minds that a gadget or an automobile or an airplane or a type of building is good, they immediately want to produce more of that particular article than anybody else in the world and faster. This urge has expressed itself in the development of traveling forms that have made possible mass production of buildings on a scale hitherto unknown. The barrel-shell roofed building, with all stiffening ribs above the deck, lends itself particularly well to such construction methods.

In Fig. 4 is shown the interior of one of several units of an army supply depot, each of which is 182 ft. wide and 1,562 ft. long. It was built in 36 calendar days with moving forms. During this 36-day period, the contractor worked on a 5-day a week schedule, and several rainy days and holidays intervened.

Such speed records have not been confined alone to shell roof structures. Over 80 acres of building were constructed with a juggernaut-like traveling form in six months, during fall and winter weather. A building

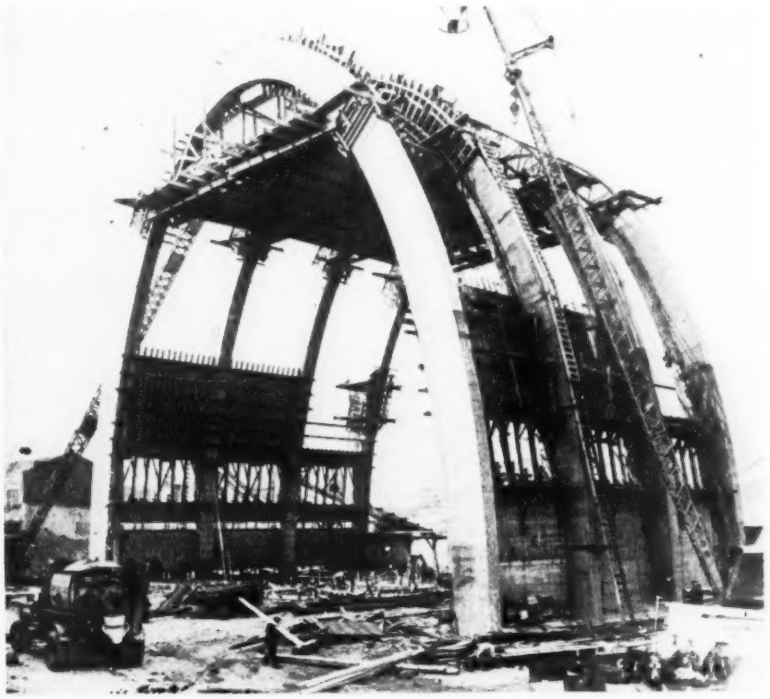


Fig. 6. Self-supporting structural steel reinforcing was used in these concrete arch ribs to obviate the use of high shoring. The parabolic shape of the ribs was to conform with internal arrangement of equipment.

Fig. 7. Eight continuous reinforced concrete rigid frames, each having seven 130-ft. spans with a clear height of 30 ft., support precast concrete joists and slabs for the roof of this flight hangar.

Fig. 8. Airplanes are dwarfed under the 160-ft. span, reinforced concrete shell roof of this hangar, which itself is almost miniature by comparison with the great thin-shelled structure shown in Fig. 9.

on which this tremendous form was used is shown in Fig. 5. The ribs of the concrete arch roof can be seen on the underside of the deck. These ribs made it necessary to lower and raise the forms for each forward movement. The ingenuity of the form construction made it possible to move the forms vertically and horizontally with a minimum of time and effort, as evidenced by the speed of construction. Typical bays of the building were 30 x 38 ft., while some bays were 30 x 60 ft. in order to accommodate equipment and manufacturing operations.

Utility expressed by design

There has been much talk about form conforming with function, but for the most part little has been done. Occasionally, however, we find those with sufficient courage to do what they believe should be done. The structure shown under construction in Fig. 6 is a pertinent example.

The arrangement of the conveyors and other equipment within the building closely conform to a parabola. The frankest approach to the problem of economically enclosing the space occupied by the equipment was therefore an arch structure approximating a parabola; so it was done with concrete. No other material could have been as readily adapted to the desired shape. Self-supporting structural steel reinforcing was used for the arch ribs to obviate the need for very high shoring. Forms for the concrete were hung from this reinforcing, as can be seen in the photographs, as Fig. 6.

War structures portend future

Knowledge gained through experience with unusual conditions in wartime will be valuable in the future in the design of conventional structures. Great door openings 45 ft. high and more than 200 ft. long are almost everyday requirements for modern hangars, and there seems to be little doubt that the giant airplanes of today will be dwarfed by their progeny of tomorrow. Concrete hangars like the multiple span continuous rigid frame type shown in Fig. 7, with its series of 130-ft. spans supporting precast concrete roof construction; the arch-type shell structure shown in Fig. 8, with its 160-ft. span, and the great hangar shown in Fig. 9, with its 291-ft. span arch ribs supporting an incredibly thin concrete shell presage the future.

Fig. 9. These hangars with their reinforced concrete arches of 291-ft. span carrying a concrete shell only 3½ in. thick at the crown presage the structures that will be needed to house the aircraft of the future.

Developments in Welded Steel Construction

La Motte Grover
Structural Welding Engineer, Air Reduction Sales Co.,
New York, N. Y.

***Contents in Brief**—Greater use of structural welding seems inevitable as a result of the background of experience, trained personnel and improved equipment accumulated by the shipbuilding industry during the war. In addition, test information from the laboratory and observations on ship fractures confirm and supplement present-day field and office techniques.*

EXPERIENCE WITH WELDING in shipbuilding and data obtained through research have been acquired during the war at such a rapid rate that at least 20 yr. of normal activity in the steel industry would be required to equal it. Since the shipyard experience is also largely applicable to welded bridge and building construction, a rapid expansion of structural welding seems inevitable.

It is quite well recognized that prior to the war the main factor that discouraged a more rapid adoption of welding in structural steel fabrication was the rather extensive change in equipment, organization and training of personnel required for a full realization of the economic advantages of welding. In fabricating and erecting 12,000,000 tons of steel for some 4,000 large welded merchant ships, and in building more than 60,000 Navy ships and many other marine structures, such as floating dry docks, shipyards drew heavily upon the personnel of the structural steel fabricating industry. Many structural steel shops devoted their entire capacity to welding in the execution of contracts for ships or their parts, barges, hoists, derricks, gun mounts, and various other kinds of war production. Those who have kept their houses pretty well in order and have attempted to control their costs and analyze them have become especially aware of the economic advantages of welding. They are now equipped and organized for this work and have extensive experience in its control.

Value of duplication proved

Before the war it was commonly thought that welding held its greatest advantage in work that did not involve enough duplication to warrant making elaborate templates and other provisions for punched work. In war production, the same great advantage of duplication has been demonstrated for welded fabrication. Although few of the very large jigs, fixtures, welding platforms and platens of shipbuilding will find a counterpart in normal structural fabrication, many of the smaller jig-type floors, girder positioning devices and other fixtures have already been used to good advantage.

The greatest savings in the use of welding have been accomplished through reduced cost of steel material and its fabrication. On the other hand, with the erection methods that have been used for welded building frames, only a slight advantage has

U. S. Navy photo

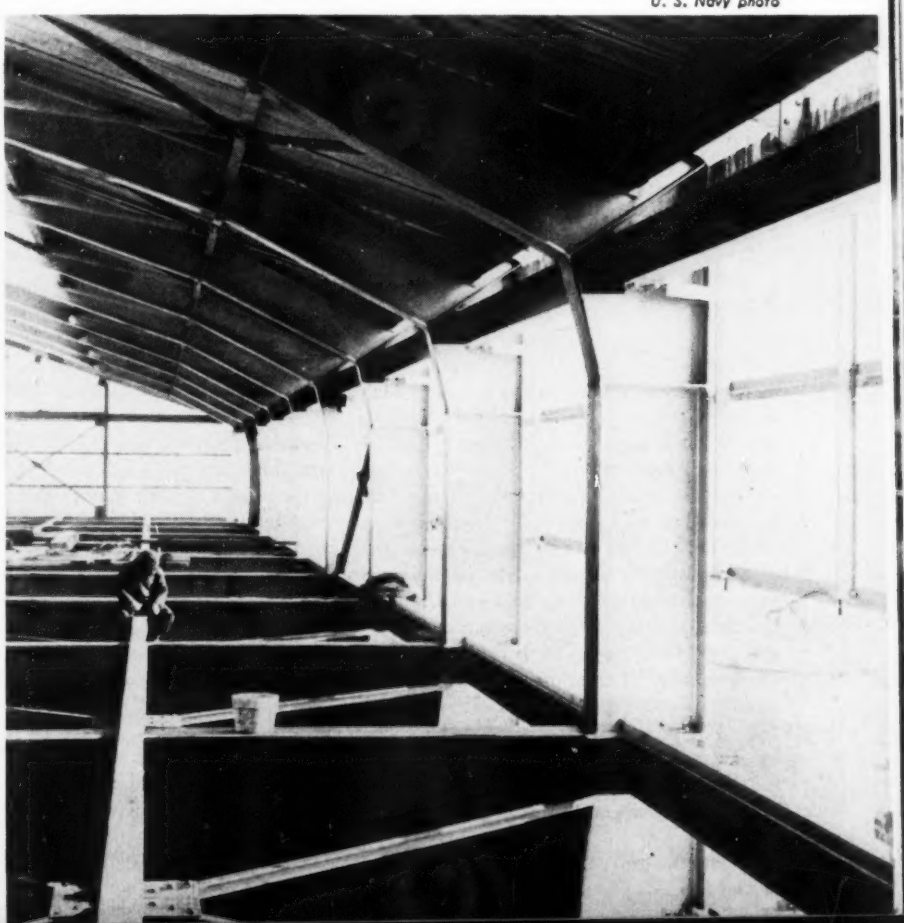


Fig. 1. Welded rigid-frame members, such as those used in the structural shop of the Boston Navy Yard lend themselves to long-span construction providing clear floor areas.

U. S. Navy photo

Fig. 2. Similarity between some of the framing members used in drydock construction and those used in buildings indicates that marine welding practices are also applicable in structural work.

been found in erection costs. However, by using welding for field connections as well as shop connections, fabrication costs can be reduced further.

Because of the applicability of ship welding experience to structural work, a vast reservoir of personnel is available, graduates of extensive training programs organized around the systems used for welded construction. The result is that today there are many more steel workers trained and experienced in welded construction than in riveted work.

The very great improvement in the construction and service records of ships built later in the program is evidence of the effectiveness of the personnel training programs and the practical systems of engineering control that were set up to insure good workmanship in erection and fabrication. As war production slackened, there was a gradual weeding out of incompetent and less adaptable workers, leaving a more than adequate supply of competent welding operators, oxyacetylene cutters, fitters and other craftsmen who are well experienced in both the fabrication and erection of welded structures,

Electrode facilitates a.c. welding

Other wartime developments worthy of note occurred in welding equipment. In the manual welding of plain carbon and low-alloy steels, there has been a decided trend toward a.c. welding, encouraged by the development of an AWS-ASTM Class E6011 electrode for all positions of welding. This electrode will produce a weld metal of the high quality that was previously attainable in a.c. welding only in the flat position and in making horizontal fillet welds. Continual improvements have been made in other electrodes, welding transformers, generators, and accessories, to facilitate welding operations and improve their economy and control.

In shipbuilding, with many long seams to be welded in plating, there has been a very extensive use of automatic welding equipment, mostly of the submerged arc type. It is problematical whether fabrication operations involving much less welding of long continuous butts and fillets can be organized to make automatic welding economical in the structural steel fabricating industry, where it had been tried without much success before the war.

Allowable stresses proved low

A great deal has also been learned as a result of laboratory tests on welded members in the past few years. Experience as well as research has demonstrated that the unit working stresses for welds, as established by the American Welding Society in its *Code for Arc and Gas Welding in Building Construction* and in the American Institute of Steel Construction specifications, are very conservative. Considerably higher effective unit stresses and comparatively small fillet welds have been used for a long time in the building of welded warships. When casualties have occurred in ships, fractures have been propagated in base metal, except in a few very obvious cases of grossly deficient welds.

Repeated stress tests under near static conditions (small range in stress and only a few thousand repetitions), show fatigue values for both butt welded and fillet welded joints well above the yield point stress. Hence, arbitrary increasing of weld sizes above specification requirements should be avoided, for the additional welding constitutes a needless waste of time and money and, in some cases, can lead to undesirable distortion that may be difficult or costly to correct.

End connections tested

Extensive investigations of full-size welded connections for building construction and various details used for them have been in progress for about 12 yr. at Lehigh University under the auspices of the Structural Steel Research Committee of the Welding Research Council, which is sponsored by the Engineering Foundation. Recently published reports, together with some 14 previous ones published since February, 1934, provide a comprehensive appraisal of the comparative merits and the behavior under static load of various types of beam end connections for building con-

struction. Since all of the types tested have been used successfully in practice for a number of years, there is a background of experience to supplement the results of research.

Through the research at Lehigh and the studies based upon it, a more efficient and more rational method of design has been developed for welded building connections than has been used heretofore in steel building construction. At the same time, through the provision of standardized details and design diagrams, the designer has been relieved of much of the routine calculations that were once necessary. Further, there has been provided a sound basis for the design of connections for rigid and semi-rigid framing.

In a study prepared by H. W. Lawson, "Standard Details for Welded Building Construction," *Journal* of American Welding Society, Oct., 1944, the results of the Lehigh tests have been analyzed. The most suitable types of beam connections have been selected for three general classifications of use: (1) Rigid connections for continuous or fully restrained framing; (2) virtually flexible connections for "conventional" or "simple" framing; (3) semi-rigid connections for partially restrained framing, such as those used for wind bracing (Fig. 4).

Such semi-rigid connections, if possessing a dependable and known moment capacity, may also be employed to reduce mid-span moments and increase end moments to the point where they approach equality, thus providing for a better balanced design with lighter beam sections than are required in many cases for either fully-restrained or conventional framing. (Method of analysis presented in *ENR* Oct. 10, 1940; *Journal* of A.W.S., Oct., 1939; *Proceedings* of A.S.C.E., Mar., 1941.)

Some standard corrections

Simple-beam connections, which lend themselves most easily to standardization, have now been designed for all wide-flange beam sections, American Standard I-beams and channels, and miscellaneous mill beams, light beams and joists. To meet the need that has been expressed repeatedly by structural engineers, Air Reduction plans to publish this data soon in a comprehensive manual of design for welded structures.

These standardized details include stiffened seats and also "flexible" angle seats, which have been proved dependable by tests and are deemed suitable for use without arbitrary limitations as to maximum reaction, when properly designed. With these seats, flexible top-angles are provided, which serve merely to hold the beam in proper position and to prevent end twisting, without being designed to share in the support of the beam.

Also included are "flexible" framing angle connections, quite similar to standard riveted framing angles but of a reduced size made possible by the inherent compactness of welded connections, which reduces eccentricities. Somewhat more expensive than top-angle and seat connections and somewhat less efficient as demonstrated by tests, framing angles are

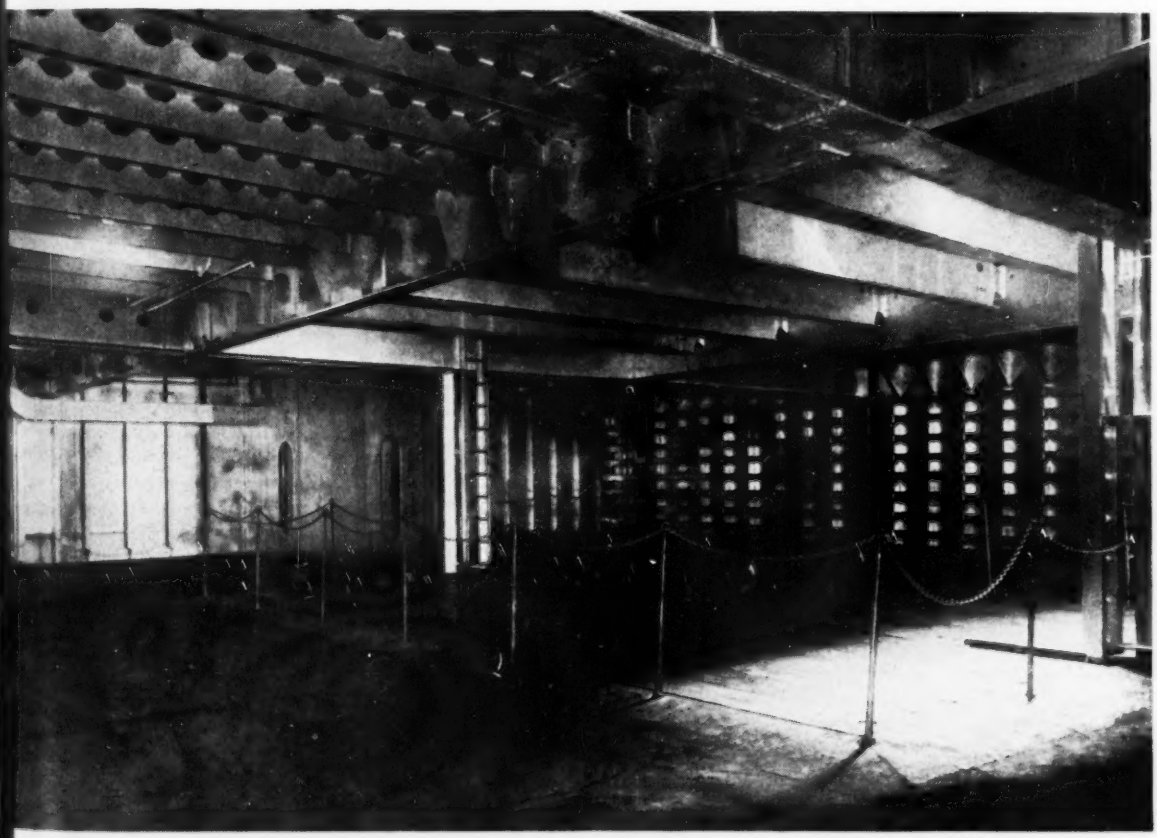


Fig. 3. Resemblance of steel framing used in hold of a ship to that in buildings suggests that personnel and techniques employed on the former may be shifted to the latter.

used principally where there is insufficient clearance for a beam seat or for the welding for it.

Diagrams have been prepared for the proportioning and welding of parts of special connections, taking into consideration the eccentric forces acting upon various geometric arrangements of weld groups in somewhat the same manner as these eccentricities are treated in riveted connections. However, some eccentricities that are customarily disregarded in riveted connections are taken into consideration in welded design.

A large part of the information developed by research on welded construction is also applicable to riveting. One important point brought out is that although attention has seldom been focused upon the occurrence of plastic deformation and local self-limiting stresses beyond the yield point, such as are involved in "flexible" welded connections, this behavior has always occurred in standard riveted beam connections.

Causes of ship fractures

It is quite well known that some construction cracks have occurred in welded ships, most of them in wide expanses of heavy shell and deck plating and at details that impose severe constraint against ductile behavior, under conditions greatly different from those involved in ordinary building frames. Serious or potentially serious fractures have also occurred in a small percentage of the ocean-going merchant ships built during the war. Virtually all of these have been in vessels built during the earlier part of the program when production organizations and personnel were inexperienced and before extensive improvements had been made in details of design.

Through many exhaustive surveys and investigations, together with a vast amount of research, the causes of these difficulties have been quite well established. Much of the research information has been held confidential during the war and has not yet been released. In effect, the remedy for keeping out of trouble lies in the avoiding of severe notch-like details, very abrupt changes in section and other details or geometrical arrangements that would impose very severe multi-directional stresses or constraint against ductile behavior. When quite severe conditions of this

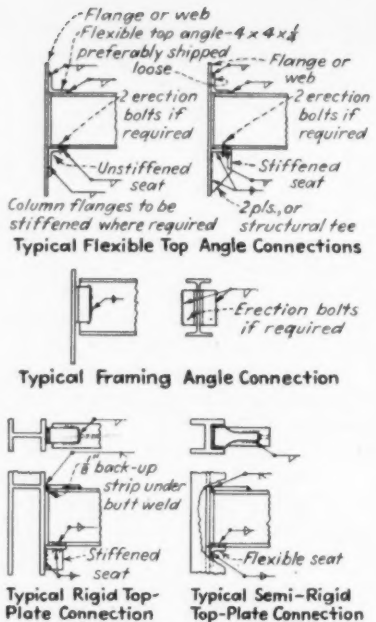

Flange or web
Flexible top angle-4 x 4 x ¼
preferably shipped loose
2 erection bolts if required
Unstiffened seat
Column flanges to be stiffened where required
Flange or web
2 erection bolts if required
Stiffened seat
2 pl's, or structural tee
Typical Flexible Top Angle Connections
Erection bolts if required
Typical Framing Angle Connection
⅜" back-up strip under butt weld
Stiffened seat
Typical Rigid Top-Plate Connection and Stiffened Seat
Flexible seat
Typical Semi-Rigid Top-Plate Connection and Flexible Seat

Fig. 4. Welded end connections for beams fall into three classification depending on the amount of restraint against rotation.

kind are unavoidable, it is especially important to make sure that the materials possess sufficient notch-toughness at the lowest anticipated service temperature to permit ductile behavior in the presence of stress concentrations and constraint.

Most structural engineers are aware of a need for ductility in steel materials, but they do not generally understand fully the reasons for requiring adequate ductility. Often, their conception of ductile behavior is based inadequately upon the elongation measured in small conventional acceptance tests of 0.505-in. diameter tensile specimens subjected virtually to uni-axial stresses in the vicinity of the gage marks.

Conditions of geometrical shape

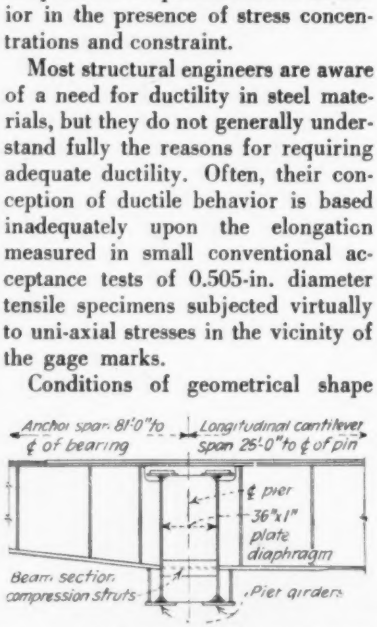

Anchor span 81'-0" to ℄ of bearing
Longitudinal cantilever span 25'-0" to ℄ of pin
℄ pier
36"x1" plate diaphragm
Beam section compression struts
Pier girders

Fig. 5. Local geometric constraint at junction of longitudinal cantilever girders with transverse supporting girders over piers of all-welded Connecticut bridge is relieved by openings coped in the longitudinal members.

and resulting stress distribution may be very much different in an actual structure (Fig. 5). Also, research has shown that the behavior of material is greatly altered in many cases by such differences in conditions. Two pieces of steel that undergo the same elongation in a conventional tensile test may exhibit a great difference in "ductility" as measured by other, more exacting tests which more nearly reflect conditions in an actual structure. For more rational and balanced design, it is therefore necessary for engineers to develop a more accurate concept of the practical meaning of "ductility" as reflected in the behavior of material in a structure, particularly when large, heavy parts and members are involved.

Fortunately, the geometric proportions and dimensions of ordinary structural members and connections in buildings are such that little special consideration need be given to them, of the kind that has been discussed above. However, severe notch-effects, which actually set up constraint and multi-directional stresses as well as more commonly recognized stress concentrations, cannot be disregarded in any type of construction, steel, timber or concrete.

Although more importance was attached to the effect of residual stresses in some of the earlier reports on ship fractures, careful analyses of research and experience, including casualties resulting from enemy action during the war, have led to the conclusion that under normal conditions residual stresses can be no more than a minor contributing factor to failure in an engineering structure—probably only "the straw that breaks the camel's back" when other contributing factors become intolerable. It is believed by many technicians that residual stresses cannot under any practical circumstances be of consequence in this regard.

The effect of the research of the last few years has been to verify some beliefs and suspicions based purely on experience and to dispel fears based upon incomplete information. With the new data available, increased confidence in the utility, safety and economy of welded steel structures, together with the experience of fabricators and availability of trained personnel, should lead to extensive use in peacetime building of this type of construction.

What to Expect in New Building Materials and Equipment

***Contents in Brief**—Knowing that under the exigencies of war many engineers, architects and contractors have found it difficult to keep fully informed on the latest technological improvements in the building field, we invited 550 manufacturers to send us data on recently developed materials of construction and installed equipment for review. From a survey of this data, we gain the impression that a great number of new products cannot be expected to appear on the market in the very near future, but that many new uses are likely to be found for the older materials.*

WITH INDUSTRIAL BUILDING increasing faster than any other form of heavy construction and other building increasingly active, and with engineers, architects and contractors returning again to civilian activities, owners and their designers are faced with a vexing problem. Should they build now with the older, well-known materials, installing the older, well-known equipment; should they specify new products that have proved themselves during the war; or should they wait in the hope that unannounced "super" materials and equipment may become available?

As a guide in making a decision, it will be helpful to consider the results of a survey of 550 manufacturers of building materials and installed equipment, who were invited to submit for review data on any new products that they might have. Of the group polled, only a little more than five percent reported that they are marketing anything new, or considerably redesigned, or for which a new use has been found. In effect, this means that the number of new types of building materials and installed equipment that will become available in the near future will probably be very small.

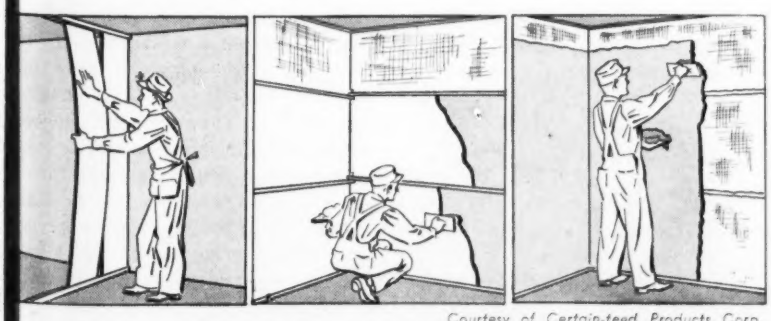
Several explanations of this situation may be offered. First, some manufacturers, fearing competition, are reluctant to announce a new product until it is actually placed on the market. Second, there is a definite tendency to avoid having a building material labeled new, because of the desire to establish a reputation of long and satisfactory service in use. Third, there is still such a great demand for the older, well-known products that many manufacturers do not consider introduction of new things at present warranted. Fourth, in some cases research projects were delayed or halted by wartime shortages. Fifth, continuing shortages of personnel, machinery and raw materials in some instances are postponing the introduction of new products.

On the other hand, almost all of the newer products reported are available immediately. Hence, the expectation of using recently developed materials or installed equipment should not logically be permitted to influence the decision of when to build.

Of the newer products, moreover, few are being placed on the market for the first time this fall. As a matter of fact, designers and builders may already have had first-hand experience with some of them, although wartime shortages and priorities have to date prevented their widespread use. In some cases new types of building design have incorporated older materials in roles different from those they had previously played. In other cases materials or equipment have been redesigned to such an extent that they may be considered new. The following is based upon reports submitted by the manufacturers.

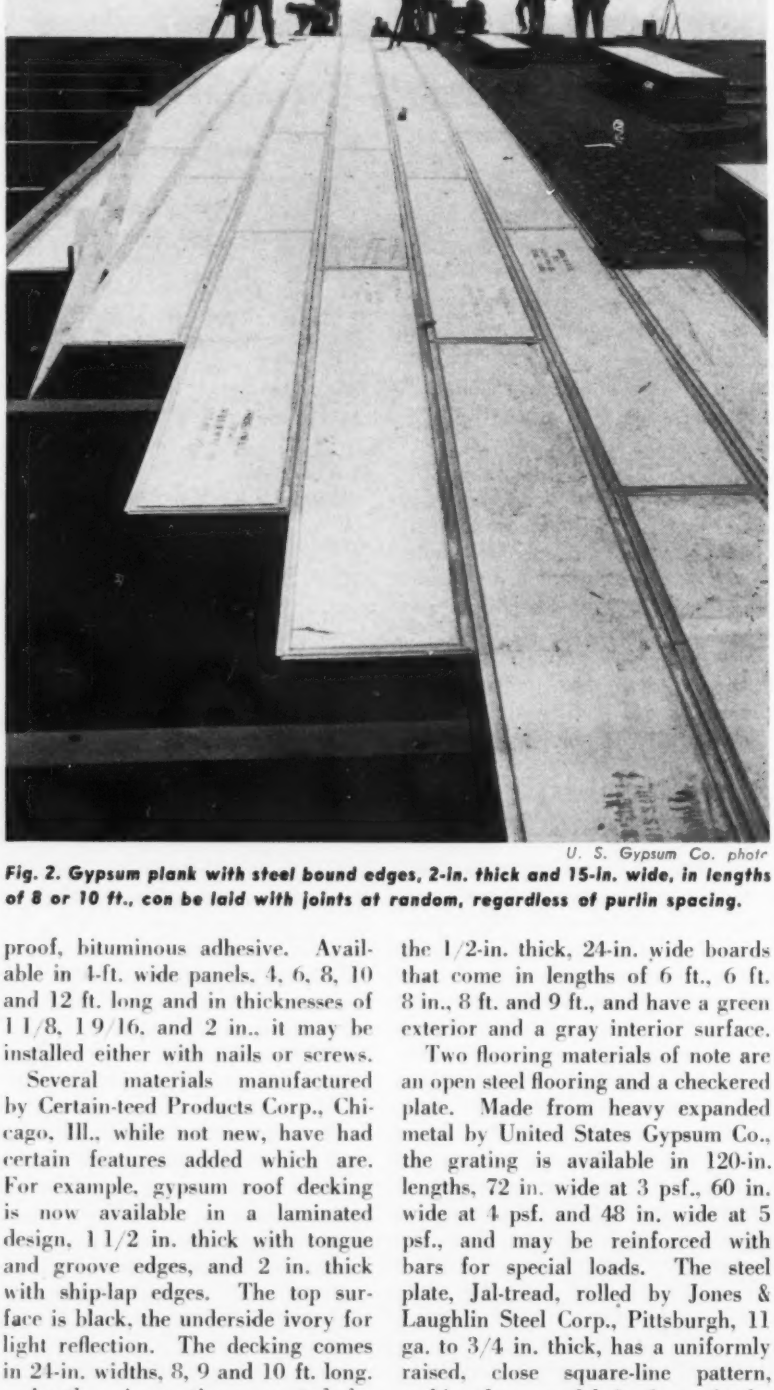
By far the greatest number of products for which a "new" claim is made find their place in floors, roofs, walls and partitions. There is, for example, a general utility building board, on the market for about two years, manufactured by the Ruberoid Co., New York, N. Y., and suitable for both exterior and interior uses. Known as Stonewall asbestos-cement board, it comes in 4x8-ft. size and in thicknesses of 3/16, 1/4 and 3/8 in., and is claimed to have uncommon flexibility for this type of material.

In somewhat the same classification is Cemesto board, a prewar new product of the Celotex Corp., Chicago, which was widely used in rush wartime buildings. It is composed of a core of cane fiber insulating board between 1/8-in. layers of asbestos-cement strongly bonded to the core with a waterproof, vapor-



Courtesy of Certain-teed Products Corp.

Fig. 1. Gypsum lath, ½-in. thick, 16-in. wide basic element of non-load-bearing 2-in. solid plaster partition, is flexed into runners fastened to floor and ceiling (left). A scratch coat is applied between temporary bracing (center). Brown coat is then applied to braced side after removal of bracing (right).



U. S. Gypsum Co. photo

Fig. 2. Gypsum plank with steel bound edges, 2-in. thick and 15-in. wide, in lengths of 8 or 10 ft., can be laid with joints at random, regardless of purlin spacing.

proof, bituminous adhesive. Available in 4-ft. wide panels, 4, 6, 8, 10 and 12 ft. long and in thicknesses of 1 1/8, 1 9/16, and 2 in., it may be installed either with nails or screws.

Several materials manufactured by Certain-teed Products Corp., Chicago, Ill., while not new, have had certain features added which are. For example, gypsum roof decking is now available in a laminated design, 1 1/2 in. thick with tongue and groove edges, and 2 in. thick with ship-lap edges. The top surface is black, the underside ivory for light reflection. The decking comes in 24-in. widths, 8, 9 and 10 ft. long.

Another innovation reported by Certain-teed is the addition to its gypsum sheathing of a water repellent quality, eliminating the necessity for using an asphalted building paper over the sheathing before applying exterior siding. Tongue and groove edges provide secure, tight joints for the 1/2-in. thick, 24-in. wide boards that come in lengths of 6 ft., 6 ft. 8 in., 8 ft. and 9 ft., and have a green exterior and a gray interior surface.

Two flooring materials of note are an open steel flooring and a checkered plate. Made from heavy expanded metal by United States Gypsum Co., the grating is available in 120-in. lengths, 72 in. wide at 3 psf., 60 in. wide at 4 psf. and 48 in. wide at 5 psf., and may be reinforced with bars for special loads. The steel plate, Jal-tread, rolled by Jones & Laughlin Steel Corp., Pittsburgh, 11 ga. to 3/4 in. thick, has a uniformly raised, close square-line pattern, making for easy fabricating. At the base of each checker is a small fillet to eliminate splitting when the plate is worked.

In quite another direction, the possibility of enclosing an entire building in steel roof deck units is posed by The R. C. Mahon Co., Detroit, Mich., as a result of wartime experience with its product as side walls. Using two layers of deck to form a double wall, insulation may be inserted against both weather and noise. Mahon steel deck plates are 12 in. wide, either 20 or 18 ga., and are made with ribs 1½ in. deep spaced 6 in. apart.

A metal deck with a tapered rib, the last product developed prior to the war by the Goldsmith Metal Lath Co., Cincinnati, Ohio, is available in 18, 20, 22 and 24 ga. iron or steel. In Metrodeck, as it is called, the center lines of the ribs are parallel while the rib itself is wider at one end than at the other. This is claimed to speed up erection by permitting the lapped joints between units to be quickly and effectively made, regardless of lengths of units.

Insulating products

Development in board form of thermal insulating materials is a recent activity of Owens-Corning Fiberglas Corp., Toledo, Ohio, its "Fiberglas PF" consisting of white glass wool compressed and bonded with an organic binding agent. It is available in thicknesses from 3/4 in. to 3 in. (according to density) and in four densities from 2½ to 6 lb. per cu. ft., for use on interior surfaces or as filler in walls.

Asphalt-enclosed board for roof deck insulation, "Fiberglas AE", is the highest density PF insulation, heavily coated with asphalt on all sides and edges. It comes in 12 x 36-in. units, 1, 1½ and 2 in. thick, which are installed by laying in hot-mopped pitch or asphalt.

In a variation of the enclosed board, the heavy density glass wool is provided with a surfacing of kraft paper securely asphalted over one entire face, along both longitudinal edges and partly wrapped over and cemented to the opposite face. The boards, 18 x 48 in., are designed to be laid on hot-mopped asphalt applied over a vapor barrier layer of of felt and asphalt (or pitch) previously applied to the roof deck. Both types of roof boards must be covered with a weathering surface of built-up roofing in the usual manner.

Somewhat allied to insulation is soundproofing, a field to which United States Gypsum Co. has introduced a war-developed product "Auditone", a slotted, wood fiber

tile available in 3/4- and 1-in. thicknesses, 12x12 in. or 12x24 in. With painted surface, it comes beveled edged, with a tongue-and-groove type for nailing and a butt type for cementing. The older USG acoustical tile, Acoustone, formed from inorganic filaments of specially processed mineral fiber, can now be obtained with added decoration in various motifs.

Inclosure products

For roof and side walls, H. H. Robertson Co., Pittsburgh, Pa., has developed Galbestos, a sheet steel to which asphalt-impregnated asbestos felt is fused so firmly that the material can be worked like unprotected metal. A weatherproof seal coat is applied to the felt at the factory.

Another inclosure material is Plastipitch protected metal, consisting of corrugated V-crimp or flat sheet steel, coated with a special pitch compound by a process developed by The Koppers Co., Tar and Chemical Division, Pittsburgh, Pa. And still a third is the corrugated asphalt siding of the Certain-teed Products Corp., Chicago, Ill., now available with a mineral surface.

The Cheney Metal Products Co., Trenton, N. J., has developed a sheet metal for exteriors by combining aluminum with stearin cottonseed pitches, pulverized slate and mica under high temperature and pressure. The 22-ga. standard sheet is 25 percent thicker, yet is said to cost 27 percent less, than 16-oz. sheet copper.

Much is also heard of new glass products, and one that has received considerable attention is Thermopane, a product of the Libbey-Owens-Ford Glass Co., Toledo, Ohio, which is composed of two or more lights of glass separated by 1/4 or 1/2 in. of dehydrated air space and hermetically sealed around the edges at the factory with a patented metal-to-glass bond. Thermopane is available for use in conventional window size or in larger units where it is desired to make the entire wall of glass.

Another glass product of interest is corrugated glass without wire, manufactured by Pennsylvania Wire Glass Co., Philadelphia, makers also of the new Penglass round "accelerator" roof ventilator. The corrugated glass without wire is said to be many times stronger than ordinary plate glass of the same thickness.

Unusually significant changes have been recorded in the field of cement and concrete making, although, so far, they have been felt more in highways and in other structures than buildings. Reference is to air-entraining cements, made by the addition of vinsol resin at the mill, a practice pioneered by Universal Atlas Cement Co., and to the several concrete admixtures that have grown in acceptability during the war. Of the latter, Pozzolith, a cement dispersing agent of The Master Builders Co., Cleveland, is designed to break up the clumps of cement particles and thus expose the entire cement surface to hydration, permitting the cement to be used with maximum efficiency. Plastiment of Sika Chemical Corp., Passaic, N. J., and Darex of Dewey-Almy Chemical Co., Cambridge, Mass., are other admixtures planned to achieve similar results.

More durable wood

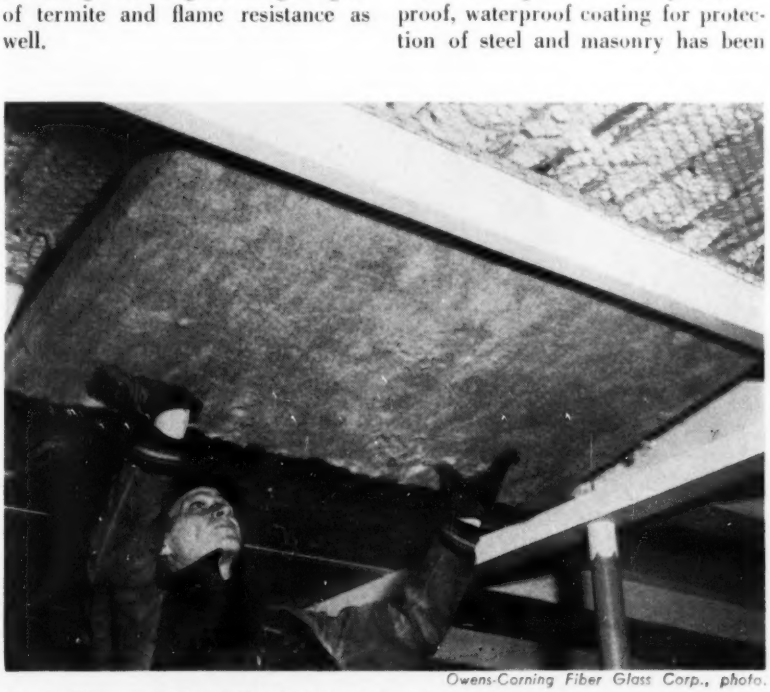
A number of new developments in wood treatment have been announced. For example, the use of chromated zinc chloride in the amount of $\frac{3}{4}$ lb. per cu.ft. has been recognized as good protection against decay. Koppers Co., Wood Preserving Division, Pittsburgh, Pa., reports that increasing the dosage to 2 lb. gives a high degree of termite and flame resistance as well.

Along similar lines is the new "pyresote" treatment developed by Protexol Corp., Kenilworth, N. J. A vacuum-pressure method, it deposits both chromated zinc chloride as the preservative and ammonium salts and boron compounds as the fire retardants in a one-movement process. Inhibitors are also included to prevent the corrosion of hardware and fastenings. Pyresote-treated wood may be handled the same way as untreated wood.

Albi Chemical Corp., New York, N. Y., manufactures a fire-retardant coating material whose effectiveness is claimed to rival chemical pressure-impregnation treatments. Known as Albi-"R", it is shipped in powder form to be mixed with water. Applied like a paint, it dries to a white hard surface.

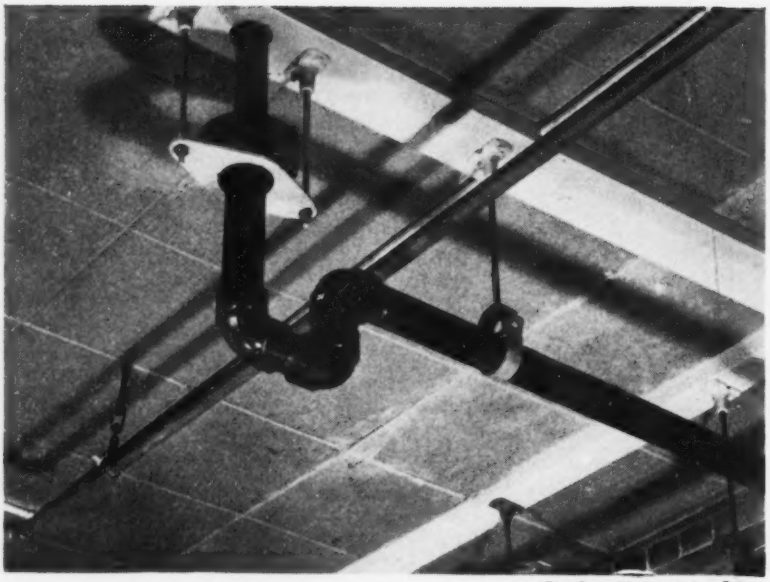
For a colorless wood preservative that will protect against termite and rot, will permit painting and is not soluble in water, the Dow Chemical Co., Midland, Mich., recommends pentachlorphenol, which is applied as a 5 percent solution in a light fuel oil. And as a companion product, there is tetrachlorphenol, which can be added to almost any paint for use in locations of high humidity, and particularly where mold-promoting conditions exist.

An acid proof, alkali proof, oil proof, waterproof coating for protection of steel and masonry has been



Owens-Corning Fiber Glass Corp., photo.

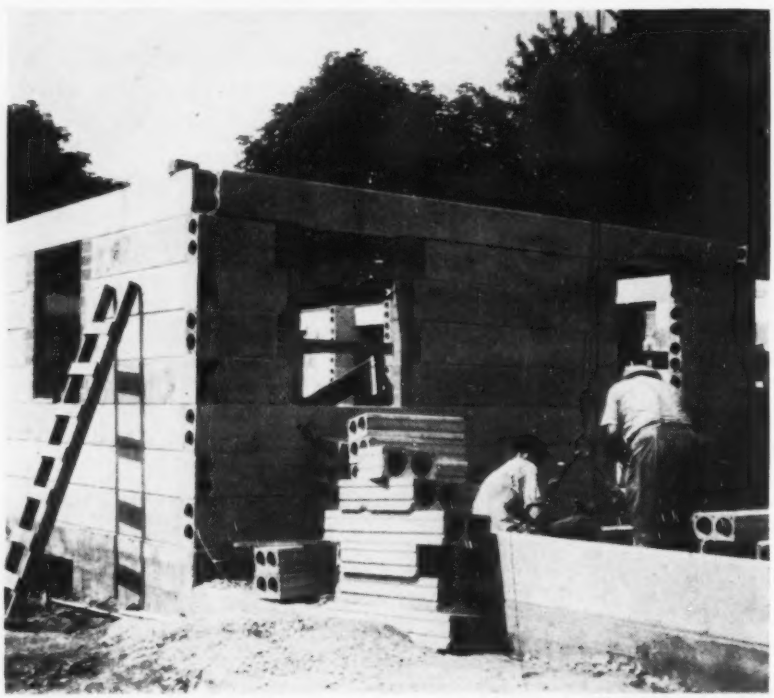
Fig. 3. Glass wool insulation in board form is said to be easy to handle and to hold together well while being applied.



The Dow Chemical Co. photo.

Fig. 4. Saran drain lines from chemical laboratory sinks replaced vitrified tile. This plastic is chemically resistant and highly durable. Plastics are special purpose materials whose selection depends upon requirements of the job.

developed by Prufcoat Laboratories, Cambridge, Mass., by combining crystal clear synthetic resins. Also produced for protecting metal and concrete surfaces, Bitumastic No. 50, a new product of Wailes Dove-Hermiston Corp., New York, N. Y., is a heavy-duty, black coating that looks like a plastic material too heavy to be readily applied, yet changes quickly to a liquid consistency upon being stirred. Another coating of interest, Drye, manufactured by Weather Seal Co., Cincinnati, used for waterproofing masonry walls is a metallic powder, mixed easily on the job with water, and is unaffected by oils or alkalies.



Flexicore Corp. photo

Fig. 5. Precast hollow concrete units, 6x12 in. in section and up to 22 ft. 6 in. long, generally used for roofs and floors, may also be used in wall construction. In manufacturing process, concrete is placed around inflated rubber tubes to form two circular cells. Weight of unit varies from 30 to 40 psf.

New designs for equipment

In the field of installed equipment for buildings, very few new products were reported, and most of the "newness" was in modifications of older designs.

Among the new equipment is the all-steel "Rol-top" door introduced by The Kinnear Mfg. Co., Columbus, Ohio, just before the start of the war. Designed to roll upward, the door is composed of rigid horizontal sections of heavy-gage galvanized steel sheets, connected so as to form a continuous hinge. It is counterbalanced, and operates on ball roller bearings.

Fairbanks-Morse & Co., Pomona, Calif., report that their pumps have been redesigned to embody many advance features, and Crouse-Hinds Co., Syracuse, N. Y., announce that they have added many items to their line of explosion-proof electrical equipment.

But it is in the field of unit heater design that most activity in building equipment design is noted. Grinnell Co., Providence, R. I., announces a new housing for its Thermolier unit heater with copper tubes, which has not been manufactured since 1942, when unit heater manufacturers were required to change to steel coils.

The blast heaters manufactured by Modine Mfg. Co., Racine, Wis., redesigned early in 1945, incorporate die-formed fins, a feature promoting greater heat transfer, thus permitting the Modine coil of smaller size, less weight and fewer fins per inch to have the same capacity and air resistance as a larger heater employing conventional flat fins. Modine also redesigned the condenser of its horizontal delivery unit heater early in 1945.

Finally, the Reznor Manufacturing Co., Mercer, Pa., reports availability of improved models of its three types of gas-fired suspended unit heaters—the propeller fan type, the blower type and the duct type. Overlapping four-blade propellers are used to give high outlet velocities. Newest of the types is the blower heater developed for duct installations where forced air flow is desirable.

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CONTRACT UNIT PRICES

What contractors are bidding on different kinds of construction work

BACK RIVER SEWAGE WORKS BALTIMORE, MD.

OWNER: City of Baltimore, Bureau of Sewers, Maryland. George E. Finck, sewerage engineer.

PROJECT: Construction of sludge tanks No. 4 and 5 for the Back River Sewage Works, Baltimore, Md. (Sanitary Contract No. 365). The two sludge digestion tanks are each 100-ft. in diameter, and each has a capacity of 200,600 cu.ft. Contract also provides for installation of three gas boilers in the present sludge control station, each with a capacity of 2,304,000 b.t.u. per hour. Work involves all necessary excavation, rolled embankment, timber and precast concrete piling, timber sheeting, concrete for structures, piping, valves, hydrants, electrical work, conduit for electrical work, and other appurtenant work required for completion of contract.

CONDITIONS: Contractor to furnish all materials and complete project in 300 calendar days. Rail, highway and water transportation facilities available to the city. Wage rates in Baltimore are: skilled labor, $1.4375 to $1.80 per hour; and common labor, 80c.

BIDS: Nine bids were received Sept. 13, 1945, ranging from the contract low of $531,136 to $740,479.

LIST OF BIDDERS:

1. Frank Angelozzi & Sons, Baltimore, Md. (contract) $531,136
2. Virginia Engineering Co., Inc., Newport News, Va 534,753
3. The Tuller Constr. Co., Red Bank, N. J. 552,812
4. The Whiting-Turner Cont'g. Co., Baltimore, Md 571,473
5. Square Constr. Co., Baltimore, Md 599,512
6. Baltimore Contractors, Baltimore, Md 613,074
7. The Baltimore Ship Ceiling Co., Baltimore, Md 618,756
8. John L. Sullivan, Baltimore, Md 670,271
9. McLean Contracting Co., Baltimore, Md 740,479

Item	Quan.	Unit Prices (1)	(2)	(3)
1. Excavation, except for sludge digestion tanks	14,600 c. y.	$2.50	$4.50	$6.00
2. Rolled embankment	12,500 c. y.	.60	.50	.50
3. Gravel refill, except for sludge digestion tanks	150 c. y.	6.00	8.00	4.00
4. Timber piles	15,000 l. f.	1.75	1.00	1.50
5. Precast concrete piles	1,600 l. f.	7.00	10.00	11.00
6. 12 x 12-in. timber sheeting	160 Mbm.	180.00	170.00	185.00
7. Class A concrete	260 c. y.	40.00	40.00	45.00
8. Class C concrete	130 c. y.	20.00	30.00	15.00
9. Reinforcing bars (except for precast conc. piling, manholes, inlets, electr. conduit manholes, sludge digestion tanks, meters, thermometers, boilers, etc.)	31,870 lb.	.08	.08	.06
10. Struct. steel, except for sludge digest. tank	805 lb.	.30	.20	.20
11. Cast iron b. & s. pipe except for Items 32 and 33	240 ton	120.00	120.00	120.00
12. C. I. flanged pipe and standard fittings, except Items 32 and 33	20 ton	300.00	275.00	250.00
13. C. I. special castings	0.5 ton	400.00	700.00	350.00
14. 10-in. black steel pipe (except Items 32 and 33)	150 l. f.	12.00	10.00	8.00
15. 8-in. black steel pipe (except Items 32 and 33)	150 l. f.	10.00	9.00	7.00
16. 6-in. black steel pipe, except Items 32 and 33)	1,660 l. f.	6.00	6.00	4.75
17. 15-in. vitrified t. c. pipe	165 l. f.	6.00	3.00	2.00
18. 12-in. vitrified t. c. pipe	820 l. f.	1.50	2.00	1.50
19. 6-in. vitrified t. c. pipe	55 l. f.	1.00	1.00	.60
20. 6-in. ex. heavy soil pipe underdrain	590 l. f.	1.60	2.00	1.50
21. 6-in. vitrified t. c. pipe under drain	400 l. f.	1.00	.60	.50
22. Cinder fill	265 c. y.	3.00	4.00	3.00
23. Manholes and inlet (except Items 7 and 31)	65 l. f.	30.00	35.00	20.00
24. 10-in. gate valves, flanged ends, ext. stems	2 ea.	180.00	200.00	150.00
25. 10-in. gate valves, bell ends	5 ea.	145.00	140.00	100.00
26. 10-in. motor operated gate valves	2 ea.	1,400.00	650.00	400.00
27. 6-in. fire hydrant	1 ea.	150.00	120.00	130.00
28. Remove and relocate 6-in. fire hydrant	1 ea.	100.00	100.00	90.00
29. 6-duct tile electric conduit	1,610 duct. f.	.50	.50	.40
30. Single duct fibre electr. conduit	580 duct. f.	.50	.40	.50
31. Electric conduit manholes	Lump Sum	850.00	800.00	700.00
32. Sludge digestion tanks complete (2)	Lump Sum	301,291.00	288,000.00	286,000.00
33. Meters, thermometer, gas boilers, etc. in sludge cont. station	Lump Sum	39,550.00	31,000.00	29,000.00
34. Electrical work	Lump Sum	2,500.00	7,500.00	4,600.00
35. Removing masonry	1 c. y.	50.00	30.00	12.00
36. Cleaning up	Lump Sum	100.00	1,000.00	1,000.00

HIGHWAY BRIDGE, VERMONT

OWNER: Vermont State Highway Dept., Montpelier.

PROJECT: Construction of steel I-beam bridge (length 69 ft. overall) with approaches surfaced with double tack coat of refined tar. Overall project length 0.383 miles. Work located on State Route No. 30, south of Newfane Village, crossing West River. Alternates were allowed for the use of dry rubble masonry or Class C concrete (Cyclopean concrete) for the structure. Contract awarded on basis of latter.

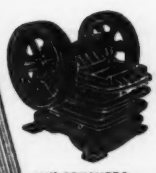
CONDITIONS: Rail and highway transportation facilities available to Newfane Village, and highway transportation to project site. Contractor to furnish all materials. Prevailing wage rates to be paid on project.

BIDS: Seven bids were received on the project, ranging from the contract low of $29,825 to $40,833. This range was for use of Class C concrete. On dry rubble masonry the range was from the low of $37,468 to $43,655.

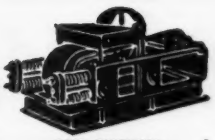
LIST OF BIDDERS: Class C Concrete

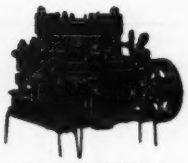
1. Frank W. Whitcomb, Bellows Falls, Vt. (contract) $29,825
2. R. F. Carpenter, Alburg, Vt 36,340
3. Kelleher Corp., Turners Falls, Mass 37,946
4. W. W. Wyman, Inc., Shelburne Falls, Mass 39,807
5. M. J. Burrington, Jr., Bennington, Vt 40,027
6. The Henley-Lundgren Co., Worcester, Mass 40,166
7. T. J. Harvey & Sons, Inc., Adams, Mass 40,833

Item	Quan.	Unit Prices (1)	(2)	(3)
1. Solid rock excavation	50 c. y.	$5.00	$2.00	$2.00
2. Common excav., incl. borrow	12,000 c. y.	.30	.43	.40
3. Trench excavation, earth	160 c. y.	2.00	1.00	1.50
4. Trench excavation, rock	10 c. y.	5.00	1.00	6.00
5. Channel excavation	860 c. y.	.50	1.40	1.15
6. Structure excavation	695 c. y.	2.00	3.00	6.00
7. Temporary bridge and maintenance of traffic	Lump Sum	1,000.00	1,200.00	2,500.00
8. Sub-base of gravel	3,000 c. y.	.60	.80	.40
9. Gravel shoulders	15 c. y.	2.00	2.00	2.00
10. Double tack coat of refined tar	3,300 gal.	.20	.20	.17
11. Concrete, Class A	116 c. y.	30.00	30.00	30.00
12. Reinforcing steel	14,070 lb.	.07	.07	.07
13. Steel superstructure (72,050 lb.)	Lump Sum	4,900.00	5,000.00	5,500.00
14. Conc. Class C (Cyclopean conc.)	513 c. y.	18.00	23.00	22.00
15. Dry rubble masonry (alternate for Item 14)	513 c. y.	40.00	25.20	25.00
16. 15-in. rein. concrete pipe	40 l. f.	2.00	2.00	2.00
17. 18-in. rein. concrete pipe	132 l. f.	2.50	2.50	2.75
18. Relaying pipe culverts	40 l. f.	1.00	.50	1.00
19. Riprap for bank protection (hvy. type, mod.)	150 c. y.	5.00	8.00	6.50
20. Cable guard rail	240 l. f.	1.00	1.00	1.25
21. Anchors for cable guard rail	5 ea.	15.00	12.00	22.00
22. Remove and reset cable guard rail	64 l. f.	.50	.80	.70
23. Guide posts	3 ea	3.00	2.00	4.00
24. Boundary markers	20 ea.	7.00	4.00	6.00


JAW CRUSHERS

PRIMARY BREAKERS


ROLL CRUSHERS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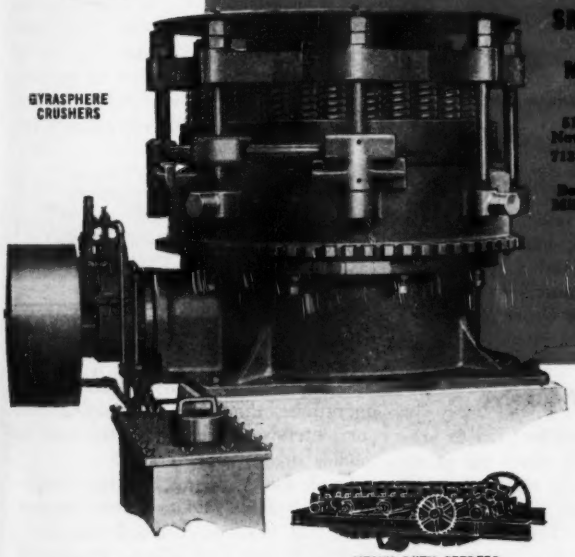
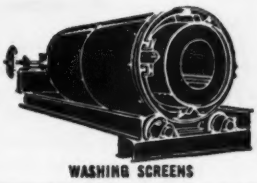
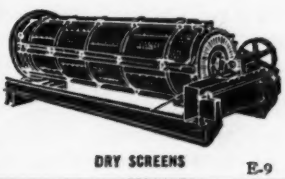
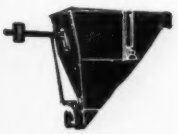

GYRASPHERE CRUSHERS

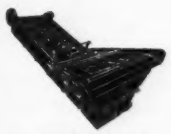
HEAVY DUTY FEEDERS

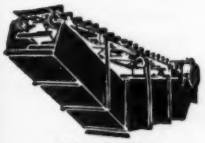

WASHING SCREENS


DRY SCREENS

PULSATORS

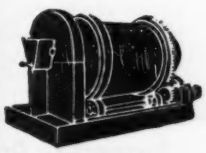

SAND TANKS


SAND CLASSIFIERS


SAND DRAGS

LOG WASHERS

SCREW REWASHERS


SUPER SCRUBBERS

E-9

New Aids to the Constructor

MANUFACTURERS' LATEST DEVELOPMENTS IN EQUIPMENT AND MATERIALS

Plate Duplicator

Designed to punch short runs and irregular shapes efficiently, the new Thomas plate duplicator will accurately duplicate holes, notches, coping,

etc., in plates and panels in runs of two to several thousand. It will handle many varieties of plates, because it requires no setting up and can be switched instantly from one job to another. Holes can be punched diagonally or in any direction and as many as eleven tools may be set in the punch. Hole sizes up to 6 in. are possible.

The duplicator has a deep throat punch with solenoid control clutch, templet pin cluster connected by shafts to a punching tool head and an all-steel table, supported by roller bearing track wheels and carrying rollers to support plates.—*Thomas Machine Manufacturing Co., Pittsburgh 23, Pa.*

• • •

Circuit Tester

Of convenient vest-pocket size, a new all-purpose circuit tester may be used for locating blown fuses, breaks in cords and appliances, radio frequency, etc. It indicates voltages from 90 to 5,000 D-C and from 60 to 500 A-C.

A General Electric neon light on top glows in varying intensities, indicating circuit conditions. The lamp lights on currents as low as one microampere.—*Amerline, 1753 North Honore St., Chicago 22, Ill.*

• • •

Perspective Drawing Machine

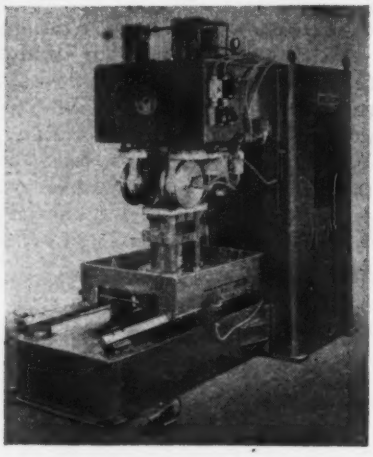
Perspective drawing may be facilitated and simplified with the new Pomeroy Stereograph, it is claimed. This device produces a perspective view as stereoscopic pairs showing length, width, depth; or, if desired, as a single perspective drawing. With it, drawings can be made to scale.

This duraluminum instrument has high carbon steel guides and rotating members. It is 32 in. long, 3¼ in. wide, and mounted between two drawing boards. At the top is a hair-line point-finder, and at the bottom a drawing straight-edge, each 20 in. long. The 23x31-in. drawing boards are mounted on square metal tubing, and are positioned by dowel pins.—*Pomeroy Stereograph Co., Inc., 1783 East 11th St., Cleveland, Ohio.*

• • •

Duplex Seam Welder

Designed for simultaneous seam welding of two or more parallel seams on one surface, a new duplex seam welder, in a wide range of capacities and sizes, is air operated and fully automatic. A duplex head accommodates two or four welding wheels. Outer wheels of larger



diameter provide clearance for the inner wheels when the former are used for welding; all wheels are free rotating, driven by contact with the moving work under welding pressure.

The movable work table, mounted on horizontal slide rails, has an integral deep coolant trough and a speed of 0 to 30 in. per minute.—*Progressive Welder Co., 3050 East Outer Drive, Detroit 12, Mich.*

• • •

Aluminum Adhesive

A new chemical may be used to prepare aluminum and its alloys for painting and lacquering by either the hot immersion method or by cold spray, brush or immersion. The hot application is said to increase corrosion-resistance, while the cold method is easy to apply to aluminum already assembled in the field.—*Technical Processes Division, Colonial Alloys Co., Philadelphia 29, Pa.*

• • •

Shovel-Crane

Mobile and speedy, the new wheel-mounted Model UC-55 "Shovel-Crane" moves over the highway up to 10 mph. This ½-yd. machine has a 6-ton lifting capacity; it is 8 ft. wide overall, has a 7 ft. 6 in. wheelbase, and, equipped as a shovel, weighs 26,350 lb.

The operator steers the crane by hydraulic power. The unit also has automatic hydraulic stabilizers and power hydraulic brakes. All conventional attachments—dragline, shovel, crane with hook-block or clamshell bucket, pile driver— may be easily applied.—*Link-Belt Speeder Corp., 307 North Michigan Ave., Chicago, Ill.*

• • •

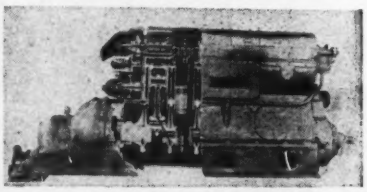
Absorbent Sweatband

By keeping sweat out of workers' eyes and off goggles, a new absorbent sweatband contributes materially to the comfort, efficiency and safety of welders and all workers on hot jobs. Made of synthetic sponge, 7¼ in. long, this band can be easily sterilized.—*American Optical Co., Southbridge, Mass.*

• • •

New Diesel Series

Now available with a power range from 190 to 250 hp. at 900 rpm., new Series 20 diesels in 6 and 8-cylinder models, D-26 and D-28, are of marine, stationary and diesel-electric types. These four-stroke cycle-type engines are



designed for heavy-duty, medium-speed operation; they are air-starting and completely enclosed, and the marine models are direct-reversing.

Fresh water cooling, a design feature of Series 20, is said to assure freedom from rust, scale or chemical deposits.—*Joshua Hendy Iron Works, Sunnyvale, Calif.*

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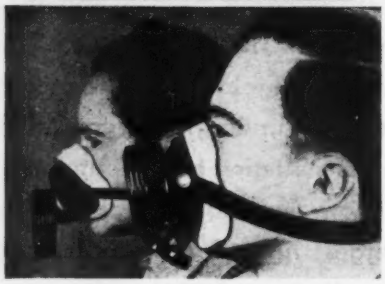

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Comfort features of WILLSON Respirators make them easy to wear. Their light weight requires little headband pressure. Compactness permits full vision—safety goggles can be worn. Washable cotton FACELET* protects face.

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Men and Jobs

Francis J. Downs, for the last four years in charge of the contractors division of the American Road Builders Association, has resigned to take a middle west sales position with Schramm, Inc. Mr. Downs is a graduate of Carnegie Institute of Technology (CE,1930). He was construction inspector for the Pennsylvania State Highway Department 1937–38. Later he was associated with the Public Works Administration as engineer-inspector and with the Pennsylvania Turnpike Commission as concrete placing inspector.

E. C. Woodward, district engineer of the Texas State Highway Department at Fort Worth, has become engineer-manager of the Fort Worth Expressway. He will make all surveys and investigations for choosing the location and designing the expressway. For 17 years he has been district engineer of the Texas Highway Department, serving at Waco, Wichita Falls and Fort Worth.

George M. Garrett, Texas Highway Department district engineer at Bryan, and a highway veteran of 25 years, succeeds Woodward as district engineer at Fort Worth.

John E. Blair, district engineer at Corpus Christi, 15 years with the Highway department as district engineer and who has recently returned from two years' Navy service as lieutenant commander, replaces Garrett at Bryan.

Thomas C. Davis, state paving engineer in the construction division in the central highway department office at Austin and with 25 years service, succeeds Blair at Corpus Christi.

Frank H. Conner of Charlotte, N. C., acting executive secretary of the Carolinas Branch of the Associated General Contractors of America, has resigned, effective Oct. 1, to become manager of the building department of A. H. Guion and Co., general contractors at Charlotte. He was graduated in construction engineering from Carnegie Institute of Technology, and went to Charlotte in 1934 as field engineer for the Portland Cement Association. Two years later he became associated with the Carolinas branch of the A. G. C. serving as assistant executive secretary until 1940 when he became acting executive secretary. Prior to going to Charlotte he was with contractors in Alabama, West Virginia, and Maryland.

Capt. Homer A. Cole, has been named State Highway engineer for Lake and Geauga counties to succeed **J. H. Mainey,** who has been promoted to engineer of the bureau of maintenance for three northeastern Ohio divisions. Capt. Cole who arrived home in May after 36 months of duty in Europe, has returned to inactive status.

J. C. Gardner of Tarboro, N. C., division engineer of the first division of the North Carolina Highway Department since July, 1921, has resigned and **T. J. McKim** of Asheboro, N. C., assistant division engineer of the sixth division since December, 1937, has been named to succeed him. Gardner, whose resignation was effective Oct. 1, has been connected with the N. C. Highway Department since 1919. Prior to being named assistant engineer of the sixth division in 1937, McKim was connected with the division in various capacities, including that of resident engineer.

Leslie A. Pettus has become manager of the Dayton, Ohio, Engineers Club, succeeding Walter C. Pfanner, who was manager of the club for 27 years. Mr. Pettus, a civil engineer graduate of Washington University, St. Louis, Mo., is a veteran of World War I and his experience also includes a period during the present war as acting chief engineer for the United States forces in Australia in relation to problems of harbor and dock facilities, highways, railroad transportation and water and electrical supply. He also is grounded in municipal engineering, having spent many years in such activity for the city of St. Louis.

Maj. John A. Long, who has been on leave of absence with the armed forces since 1942, has resumed his duties as head of the County Highway Officials and Municipal Highway Officials divisions of the American Road Builders Association. He had held this position for four years prior to his leave. Major Long was a highway engineer with the Mississippi State Highway Department until 1924. Following that, he spent three and a half years with the division of bridges of the Florida State Highway Department. For twelve years, he was highway engineer for Lee and Duval Counties in Florida.

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You've finished checking block, sheaves and drum. Now you're about to put on a new *Preformed* Yellow Strand line. Watch how its flexibility simplifies each stage of installation.

Note the willing way it comes off the reel or coil. Here's where unpreformed rope too often meets with injury. But there's no twisting, no kinking, with *Preformed* Yellow Strand—and that goes also for Lang lay and Independent Wire Rope Center constructions. Pent-up stresses have been *relaxed* by preshaping wires and strands during manufacture.

Since the ends do not flare out, limber *Preformed* Yellow Strand can be threaded quickly through blocks and sheaves... attached easily to the drum ... socketed or fastened without distorting the parts. Smooth, even first-time spooling further shortens changeover delay.

Crowning all these time-saving advantages is the *longer life* of *preformed* rope which postpones replacements, keeps men and machines on productive jobs.

Specify *Preformed* Yellow Strand by name. Get all you should in wire rope performance and economy. Broderick & Bascom Rope Co., St. Louis 15, Mo. *Branches:* New York, Chicago, Houston, Portland, Seattle. *Factories:* St. Louis, Seattle, Peoria.

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Inspect pipe lines NOW
TO SAVE COSTLY REPAIRS and LOST PRODUCTION TIME

YOU can save industries and taxpayers thousands of dollars in expensive pipe replacements and lost production and working time by inspecting war-weary sewers and drains *now*.

In the rush to gear industrial plants to peak war production, acids and industrial wastes were turned into sewers never intended to carry chemically active effluents. Because it is unaffected by chemicals and acids Clay Pipe stood the strain. But many lines are threatened with inefficiency and sudden failure due to corrosion and crumbling.

If caught in the early stages of decomposition, many lines can be salvaged by installing Clay Liner Plates, or by diverting harmful wastes into Clay Pipe lines.

Avoid such problems in the future by including Clay Pipe in plans for reconverting to peace-time production. Clay Pipe handles the common hydrogen sulphide problem and other chemical problems, because it is chemically inert. Clay Pipe cannot corrode, decompose or rust because it is impervious to acids, alkalies, gases and industrial wastes.

WRITE FOR FREE AD COPIES. Reprints of this advertisement are available at no charge to those who might want to mail copies to others interested in private and public sewer maintenance. Write us direct or contact one of the regional association offices.

National Clay Pipe Manufacturers, Inc.
111 West Washington Street, Chicago 2, Illinois

C-745-11

Elections and Activities

Organization of Syracuse Post, Am... ican Military Engineers, has b... started at Syracuse, N. Y., with the el... tion of Harold M. Rose as execut... secretary, who will act for the soci... in all matters until by-laws are p... pared and adopted and a complete sl... of officers elected.

A 6-member sub-committee to ex... dite the solution of problems of ind... trial firms and builders which m... hinder reconversion has been establis... in Columbus, Ohio, by the mayor's co... mittee on reconversion. Members i... clude: H. Ardis Creith, president ... Creith Lumber Co., chairman; T. ... Waller, president of Building Tra... Council; John A. Kite, secretary of t... Builders Exchange; Henry Ho... OPA; Lou W. Gehring, WPB; and ... Forrest Tefft, of the Claycraft Co.

C. E. Pettis, consulting engineer a... vice-president of the Ohio Society ... Professional Engineers, has been nam... president of the Toledo Society of P... fessional Engineers. Owen E. Clark w... elected vice president and Raymond ... Hall, secretary-treasurer. Directors a... G. W. Emery, William E. Hallat... Joseph R. Reece, Ross E. Schultz, J. ... Toulouse and Harland G. Wood. At ... early meeting certificates will be p... sented to engineers and surveyors w... have passed state board examinati... during the last year.

Sam E. Rogers of East Jordan, Mi... was elected president of the North... Michigan Road Commissioners' Asso... tion at its recent annual meeting ... Traverse City. He succeeds Carl ... Lindquist of Cadillac. F. E. Aemisegg... of Alden was elected vice presid... Ben D. Jeffs of Lake City was re-elec... secretary and N. E. Wicks of Irons w... re-elected treasurer.

Sixteen past presidents of the En... neering Society of Buffalo, N. Y., w... honored at a recent annual dinner ... tended by 165 members. Among the s... teen who sat at the head table w... 84-year old George B. Bassett, the ... ciety's oldest past president; Will... B. Powell, Louis A. Harding a... Newell L. Nussbaumer, commissioner ... public works. President Kenneth ... Koontz presented Clyde M. DeForest ... honorary membership for "meritori... service"—the fifth to be awarded i... ing the 51 years history of the soci...

partners in creating

• Many brilliant projects have been started with a K & E Slide Rule and the back of an old envelope. But between a new conception and its practical execution of the vital links are always the engineer and the draftsman. For through their techniques they construct the project on paper with unmistakable clarity and precision. In this their drafting instruments and equipment become part of their own hand and brain, and their partners in creating.

For 78 years Keuffel & Esser Co. Slide Rules, drafting equipment and materials have been partners in creating the greatness of America, in making possible our nationwide railway system, giant airports, fine radios for nearly every home . . . So universally is K & E equipment used, it is self-evident that every engineering project of any magnitude has been completed with the help of K & E. Could you wish any surer guidance than this in the selection of your own "engineering partners"?

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How will post-war planning affect your hydrants?

Post-war improvements are being planned in many municipalities like yours. Grade crossing eliminations, super highways, reducing hills, curves, and bottlenecks. Extensive building programs are on the blue prints. These changes will affect your fire control system. Can your fire hydrants grow with them?

MUELLER-COLUMBIAN Fire Hydrants are designed to keep pace with progress. If a new grade level makes a longer hydrant necessary, just add a new extension section to the barrel and stem. (Extension sections begin at 6" in length, increasing by 6" intervals.) One man can make the change in twenty minutes at a fraction of the usual cost for this operation. If increased industrial or building activity requires steamer nozzles for greater fire protection, it is a matter of fifteen minutes work to remove the old upper barrel section and replace with one having a steamer nozzle. The old barrel can be used in another part of the city where steamer nozzles are not needed. Keep in mind that with these changes you never need to dig up the hydrant, nor need the water be shut off.

These are but two of the many fine features of this progressive fire hydrant. For the complete story write for our latest hydrant folders. Outline all the time and money-saving features of these famous MUELLER-COLUMBIANS.

MUELLER CO.
CHATTANOOGA 1, TENN.
Decatur 70, Illinois — Los Angeles 23, Calif.

TAKES 20 MINUTES. NO WATER SHUT-OFF

Illustrations show: 1. Removing bonnet. 2. Lifting off upper barrel. 3. Adding extension stem. 4. Bolting on extension section of barrel. 5. Reassembling barrel. 6. Reassembling bonnet.

Manufacturers' Activities

WILLIAM C. VAN CLEAF, an employee of the Allis-Chalmers Co., Milwaukee, Wis., since 1912, has been appointed director for industrial relations, according to Walter Geist, president of the company. Prior to his appointment, Van Cleaf served as assistant to Lee H. Hill, former head of public relations, who resigned to become publisher of the Electrical World and Electrical Contracting.

THE ELECTRO RUST-PROOFING CORP., Dayton, Ohio, announces that Maj. Frank M. Tobin has resigned from the Army Air Force to resume his connection as production manager. Because of his previous association with the company, Major Tobin is well known in the field it serves—rust-prevention on the under-water interior surfaces of metal water tanks, standpipes, flocculators and other water-storage equipment.

ATHEY TRUSS WHEEL CO., Chicago, Ill., has changed its name to Athey Products Corp. to conform with a new line of equipment. In 1922, Athey Truss Wheel Co. began the manufacture of track-type wheels and trailer units for the earthmoving, logging, oil and sugar cane industries. The Athey line now includes highway maintenance and tractor-mounted loaders, high-speed rubber-tired heavy-duty trailers, in addition to forged-trak wheels, trailer and wagon units.

"Athey" products now will be identified by the name, "APCOR," and will include mobiloaders, force-feed loaders, rubber-tired trailers, logging cruiser wheels, forged-trak wheels, wagons and trailers, and will be sold through the world-wide "Caterpillar" distributor organization.

LLEWELLYN W. JONES has retired as treasurer of the Grinnell Corp., Providence, R. I., after having served the organization for 53 years. He will continue to act as a director, a member of the executive committee of the board, and as financial advisor. C. H. Rison, formerly assistant treasurer, who has been

employed in the company's financial division for 25 years under Mr. Jones, has been elected treasurer.

LT. COL. RALPH H. SARTOR, sales manager of the steel window and door division of Truscon Steel Co., Youngstown, Ohio, from 1938 to 1942, has been appointed commanding officer of the Army's Third Transportation zone in Baltimore, Md., succeeding Col. Murdock A. McFadden, retired.

AMERICA'S 18,726 ball and roller bearing workers who have been serving on fighting fronts will all find their former jobs waiting for them when they return, the Anti-Friction Bearing Manufacturers Association announces.

R. J. CLEARY has been appointed western district sales manager for The Buffalo - Springfield Roller Co., Springfield, Ohio. His territory will be Washington, Oregon, California, Idaho, Montana, Nevada, Utah, Arizona, New Mexico, Colorado, and Wyoming.

Mr. Cleary was recently production administrator for the production branch of the military supply department of the U. S. Engineers, Cincinnati district. Prior to this position he was a civilian administrator for the U. S. Army Engineers at Fort Belvoir. His experience covers more than 15 years in the construction field in various sections of the country.

THE TRANE CO., La Crosse, Wis., manufacturers of heating, air conditioning, air handling and heat exchange equipment, will more than double its present manufacturing facilities, building an addition to the main plant to increase its size by 40%. This will permit the fabrication of heating and air conditioning units on an assembly line basis. It will also provide greater facilities for the production of refrigeration and special heat transfer equipment. A second new building is being constructed to house factory office workers.

THE SALES DIVISION of Truscon Steel Co., subsidiary of Republic Steel Corp., is being reorganized preparatory to peacetime production. Richard P. Dodds, formerly a lieutenant colonel in the transportation corps of the U. S. Army, has returned as manager of the dealer-commodity department. Before entering service he was manager of advertising and sales promotion for Trus-

Low in sensitivity to ordinary electric light, Photo-Arc can be printed in a normally lighted room – even in your drafting room.

Peerless Photo-Arc reproductions speed up reconversion planning

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A PAYING INVESTMENT

For real economy—in terms of lasting service—equip your batching plant with Johnson's *all-steel*, sectional bins . . . They provide true portability—plus full capacity in strong construction that stands the gaff for long years of hard use.

Johnson portable section steel bins are made with one, two or three compartments. When need arises, the two-compartment bin can be quickly converted to three compartments, or vice versa, in the field.

The Improved Roadbuilders' Multiple Batcher

The Johnson Roadbuilders' Multiple Aggregate Batcher fits the bin opening of Johnson Portable Section Bins. This batcher is provided as either a 2 or 3 material batcher. Two material batchers are convertible to three materials in the field by addition of one filling valve and one weigh beam. The new weigh beam features machine faced poised weights and notched beam for greater accuracy and moisture compensation graduation on each weigh beam. This is an exclusive feature with no loose parts involved and permits prompt and convenient adjustment for moisture content.

The C. S. JOHNSON COMPANY
Champaign, Illinois
A Koehring Subsidiary

con. Paul L. Callahan, formerly assistant to Dodds, has been made manager of Truscon's advertising department.

ADOLPH G. SCHROEDER, formerly manager of the machinery and equipment department of Iron & Steel Products, Inc., has now become associated with Industrial Plants Corp., Chicago, Ill., in an executive capacity. He has been associated with the machinery industry for 25 years.

CARLISLE F. SMITH has taken an executive position at the Ward LaFrance Truck Division of Great American Industries, Inc., Elmira, N. Y., and has resigned from the American LaFrance Foamite Corp. At Ward LaFrance he will act as executive engineer.

Mr. Smith's services were requested some months ago as a technical consultant in connection with certain secret U. S. Army Engineers intelligence work in Germany and he has just returned from that investigation.

A graduate of Purdue University, Mr. Smith has had 25 years experience in the fire apparatus and automotive industry as an engineer and executive. For eleven years he was ranking manufacturing executive of the American LaFrance organization as factory manager and vice-president.

The Ward LaFrance plants have been converted to peacetime production, and are turning out commercial trucks and tractors in large quantities, as well as fire apparatus. The company has greatly expanded its engineering and manufacturing facilities, and work has just been completed on a new office building.

HEWITT RUBBER CORP., Buffalo, N. Y., has acquired a controlling interest in Robins Conveyors Inc., of Passaic, N. J., Hewitt has acquired approximately 90% of the Robins stock. Jointly Hewitt and Robins are said to have built and installed throughout the world more "long line" conveyor belts than any other manufacturer. Currently they are furnishing lengthy conveyors abroad as well as here—particularly in Russia and South America. On the Norwegian island of Spitzbergen, within 700 miles of the North Pole, the company is rebuilding a large coal handling plant previously damaged by British Commandos.

THE COLUMBIANA PUMP CO., Columbiana, Ohio, established about 1900, has been sold to Clyde Hoover of the Enterprise Manufacturing Co., it has been announced. L. C. Baker, former production engineer for the Enterprise Co., will be manager of the pump company.

C. W. GUYATT, formerly chief industrial engineer, American Steel & Wire Co., has been appointed assistant to C. D. King, chairman of operating committees, United States Steel Corp., Delaware. Guyatt will assist in the establishment of production standards for all United Steel subsidiary manufacturing companies.

MALVERN CLAY CO., Malvern, Ohio, has been sold by Harry C. Ross and H. C. Downer. The company, with a capacity of 8,000 tons a month, is considered one of the largest producers of structural tile and flue liners in the United States. New owners are: Robert C. Harsh, Minerva, Ohio, president; William J. Schilling, Malvern, vice president–production; I. H. Hart, Canton, secretary; and H. R. Cummings, treasurer.

TWO EXECUTIVES have been promoted by the Pittsburgh Piping & Equipment Co.

G. Sinding-Larsen

Gunnar Siding-Larsen has been with the company for 21 years, during which time he has engineered many unusual installations in hydraulics, high pressure steam and compressed air, and in the chemical industries. Chief engineer and member of the board since 1938, Mr. Larsen now assumes the new duties as vice-president.

Equally well-known in his field is D. M. Weir, Jr., who joined the company in 1931, after 14 years with the Pittsburgh Valve Foundry and Construction Co. He is a member of the Alumni Association of Carnegie Institute of Technology, and served in France in World War I. He has served as sales engineer for the company for fourteen years prior to his recent appointment as general manager of sales.

D. M. Weir, Jr.

KENNETH H. GAYLE, JR., has been elected a vice president of the Ingalls Iron Works Co. and its subsidiary, the

APPROVED

....by Underwriters' Laboratories

● On November 24, 1944, after rigid tests and exhaustive investigation, Underwriters' Laboratories, Inc., sponsored by the National Board of Fire Underwriters, recommended to the Fire Council of Underwriters' Laboratories, Inc., the acceptance of Lock Joint Prestressed Concrete Cylinder Pipe of the 150 lb. class in sizes from 20″ to 42″ for use in public and private waterworks and fire service systems. This recommendation was accepted December 21, 1944.

LOCK JOINT
Reinforced Concrete
PRESSURE PIPE

LOCK JOINT PIPE COMPANY

Established 1905

P. O. BOX 269, EAST ORANGE, NEW JERSEY

Denver, Colo. • Chicago, Ill. • Kenilworth, N. J. • Kansas City, Mo. • Rock Island, Ill.
Joplin, Mo. • Valley Park, Mo. • Cleveland, Ohio • Hartford, Conn. • Navarre, Ohio

SCOPE OF SERVICES Lock Joint Pipe Company specializes in the manufacture and installation of Reinforced Concrete Pressure Pipe for Water Supply and Distribution Mains in a wide range of diameters as well as Concrete Pipe of all types for Sanitary Sewers, Storm Drains, Culverts and Subaqueous lines.

COOK

ENCLOSED IMPELLERS

Any impeller designed without a shirt requires a delicate micrometer adjustment because the impeller vane must mate with the surface in the bowl within thousandths of an inch, and no wear can be compensated for, because any further adjustment *will not correct the wear* which is not concentric with the impeller rotation.

Each Cook Enclosed Impeller is mathematically designed and hand finished to give *maximum* upward *lift* to the water column. Streamlined passages through the bowl minimize friction and turbulence, *deliver greater gallonage at less*

In every last detail Cook Turbine Pumps are a rare combination of sound design and excellent material, produced with genuine pride in precision workmanship. Yet with all their advantages, *Cook Deep Well Turbine Pumps cost no more than the ordinary kind!*

Note how Cook Enclosed Impeller provides leak-proof, fully enclosed water passages, rotating as a single unit.

In the field a simple adjustment of the Cook Head Shaft Nut raises the impeller in scale graduations, so that a seal is provided between the skirt and the bowl. For skirt wear the impeller can be lowered so that the end seal can compensate for wear.

Write for literature and name of nearest dealer.

A. D. COOK, INC.

DEEP WELL & INDUSTRIAL TURBINE PUMP DIVISION

Lawrenceburg, Indiana

Steel Construction Co., and will h charge of northern division sales exports, with offices in New York. has been sales and export manager the companies. Mr. Gayle is a gra ate of the Virginia Military Insti bachelor of science in civil engin ing, and was formerly connected w the American Bridge Co., Penco Pa.

THE TIMBER ENGINEERING CO., W ington, D. C., has announced the tra fer of Canadian distribution rights timber connectors and other produ from V. H. McIntyre, Ltd., to J. Goodman, Toronto engineer.

A graduate of Queens Univers Kingston, Ont., with a degree in ci engineering, Goodman spent three ye with the McNamara Construction C Toronto, in charge of purchasing a later as project engineer.

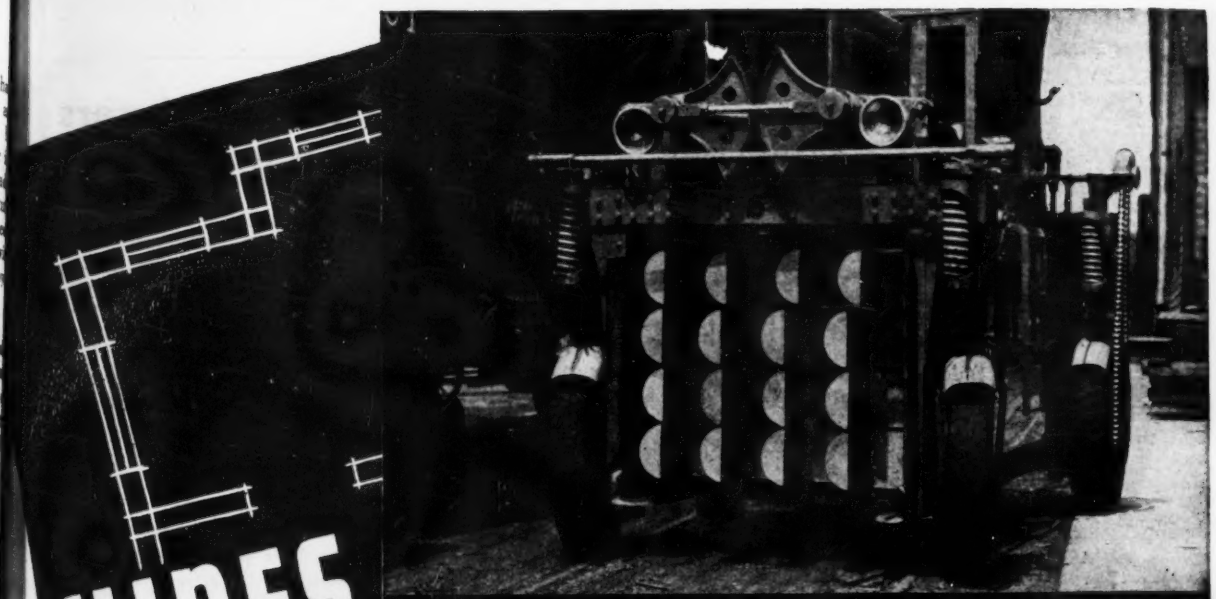
FRANCIS O. WYSE, 48, publicity ma ager for the Bucyrus-Erie Co., M waukee, Wis., for the last twenty ye died recently.

A. L. MCKAY, former general ma ager of the Kaukauna, Wis., Machi Corp., has been elected president succeed Lt. Col. Ralph J. Kraut, re cently discharged from the Army. C Kraut becomes president and gener manager of the Giddings & Lewis M chine Co., Fond du Lac, Wis.

THE RICHKRAFT CO. has announc the opening of a west coast office the Pacific Building, Oakland, Calif., under the management of C. A. Cook, who was graduated from the civil engineering school, University of Illinois, in 1932. He joined the Sisalkraft Co. in 1933 and was the San Francisco salesma for that company from 1939 until 194 His experience covered merchandising sales and service of building papers.

The Richkraft Co. manufactures building papers, and sells a compound for curing airport runways, and machines for handling it.

LOUISVILLE CEMENT CO., Louisville Ky., has announced that T. B. Kuykendall, who has been a cement salesman in southern Indiana since 1942, will head a new department to sell crushed rock for building, ballast, agricultural use, etc. The company's three southern Indiana plants have a capacity of 1,500,000 tons annually, according to President E. D. Hill.



These sub-assembly units for Panama Canal barges were accurately machined from large timbers by Hines Planing Mill in Chicago

HINES

"[illegible]AB"

Woodworking

Resiliency and strength at low cost are the vital qualities you get when you specify prefabrication assemblies made of wood —plus speed and precision when the wood working is done by Hines. Backed up by reliable sources of supply for every species of lumber, Hines is well equipped to follow the exacting details of any large construction job. Write, wire or phone for a Hines lumber specialist for full information.

No matter how difficult the shapes Hines is equipped to follow details with precision and speed

PLANTS STRATEGICALLY LOCATED ★

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DOING IT WELL
Fuller Transmissions owe their smooth, quiet performance and long wear-life to many years of *specialized* experience represented in every detail of their design and construction. Fuller has always recognized the advantages of doing one job and *doing it well* . . . specializing in a single type of product . . . giving undivided attention to the many important details essential to the most efficient performance. That's why many leading truck manufacturers and operators look to Fuller *first* for transmissions and auxiliaries that meet the most exacting requirements in all types of trucking service.
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ERIE PORTABLE AggreMeters
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AggreMeters · Buckets · Concrete Plants · Traveling Cranes

Manufacturers' Publications

Construction Machinery Industry—A booklet contains a speech on "The Outlook for the Construction Machinery Industry" by E. R. Galvin, president of the Tyson Bearing Corp., who considers the outlook good for these reasons:

1.—Improvements in equipment from intensive military use of construction machinery.

2.—Expanded foreign markets, resulting from widespread "sales demonstrations" by our armed forces construction battalions.

3.—The vast backlog of road construction work that has accumulated.

4.—The existing shortage of road machinery equipment.

5.—Our competitive advantage through control of patents.

6.—A domestic demand that warrants volume production.

7.—The absence of reconversion problems.

8.—The existence of adequate merchandising outlets and factory trained service manpower.—*Tyson Bearing Corp., Massillon, Ohio.*

Self-Bonding Flooring—A bulletin describes a flooring that can be applied directly over old concrete and practically any other sub floor. Old pitted and cracked cement floors do not have to be chipped away nor does any adhesive or bonding agent have to be used in laying this material, as it bonds directly. It is said to have many of the favorable characteristics of concrete, but it does not dust, crack, pit or crumble. Because of a special colloidal composition it is resilient and hence highly resistant to vibration as well as direct impact and the wear and tear of traffic.—*Continental Asbestos & Refining Corp., 1 Madison Ave., New York 10, N. Y.*

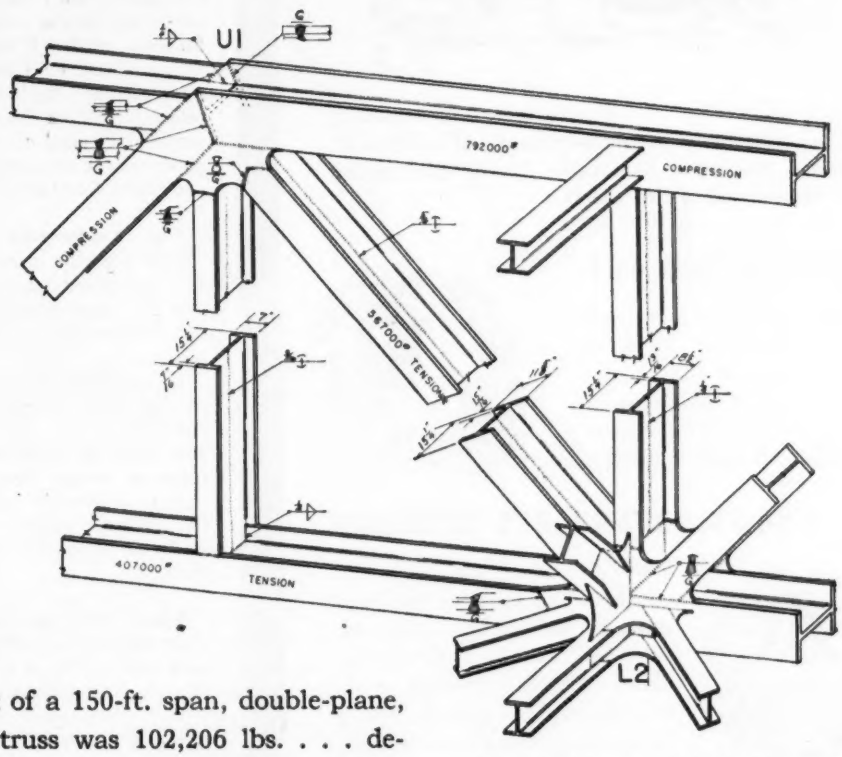
Heat Exchangers—A bulletin covers instantaneous and storage hot water generators, closed heat exchangers and converters and open heat exchangers. Heating capacities of regular models range from 60 to 4,400 gph.; storage capacities, 25 to 1,904 gals.—*The Brownell Co., 426 N. Findlay St., Dayton 1, Ohio.*

Diesels for Municipal Plants—During the war, the government used practically all of the diesel engine output for ships and for electric generating sets to be sent overseas. With the end

"TEACH"... *he says*

HERE, PRESIDENT COMACHO, is a source of education for any man interested in producing better structures at lower cost with Arc Welding:

HOW TO SAVE 21,806 LBS. IN TRUSS WEIGHT



Net weight of a 150-ft. span, double-plane, veted jack truss was 102,206 lbs. . . . designed for an equivalent uniform load of 6,000 s. per linear foot. Designed for the same conditions and strength of arc welded construction, the truss weighs only 80,400 lbs. . . . aving 21.2% in truss weight.

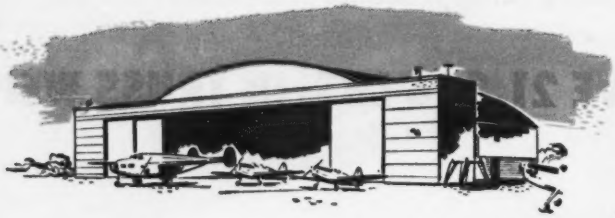
The design and fabrication of this jack truss, *part of which* is shown above, are discussed in detail in Structural Studies 100 and 101. Free on request. Ask for these and future Studies on your business letterhead.

HE LINCOLN ELECTRIC COMPANY • DEPT. T-1 • CLEVELAND 1, OHIO

America's greatest natural **recourse**

ARC WELDING

They've Clipped Fire's Wings

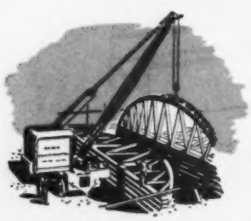


This hangar isn't going to burn down. It is constructed of wood that has been pressure-treated with Minalith* fire retardant, making it flameproof. That's good going wherever the hazard of fire exists.

THE NAVY USED A LOT

Blimp hangars, warehouses and other buildings all over the world were given this same kind of protection. It has paid dividends in greatly reduced fire losses. Peacetime builders can profit similarly.

WOOD'S ADVANTAGES RETAINED



Wood buildings go up easily and fast. Construction has high strength with light weight, resilience, excellent insulating value. Minalith-treated wood will become increasingly available as demands for war slack off.

AMERICAN LUMBER & TREATING COMPANY

CREOSOTING

FLAMEPROOFING

WOLMANIZING

*Registered trademarks

1649 McCORMICK BUILDING, CHICAGO 4, ILLINOIS

of this demand, the industry will retu to its prewar markets. The first of the to be explored is the field of municip light and power plants. A booklet this subject has been issued. Futu booklets will deal with diesel engi applications in ships and boats, loc motives, the oil industry, and in vario stationary situations.—*Diesel Engi Manufacturers Association, 1 LaSal St., Chicago 2, Ill.*

Shovel-Crane-Dragline—A specific tion bulletin has been issued on a ½-y self-propelled rig which combines th functions of shovel, crane and dragli with mobility, efficiency and easy ha dling qualities. Included in the 2-colo folder describing the new machine is series of detailed descriptions coveri power flow, construction and operati —*General Excavator, Marion, Ohio.*

For Engineering Construction—Timed with the release of addition steel for culverts and other metal pro ucts, is a new 60-page catalog on ce tain products for engineering constru tion.

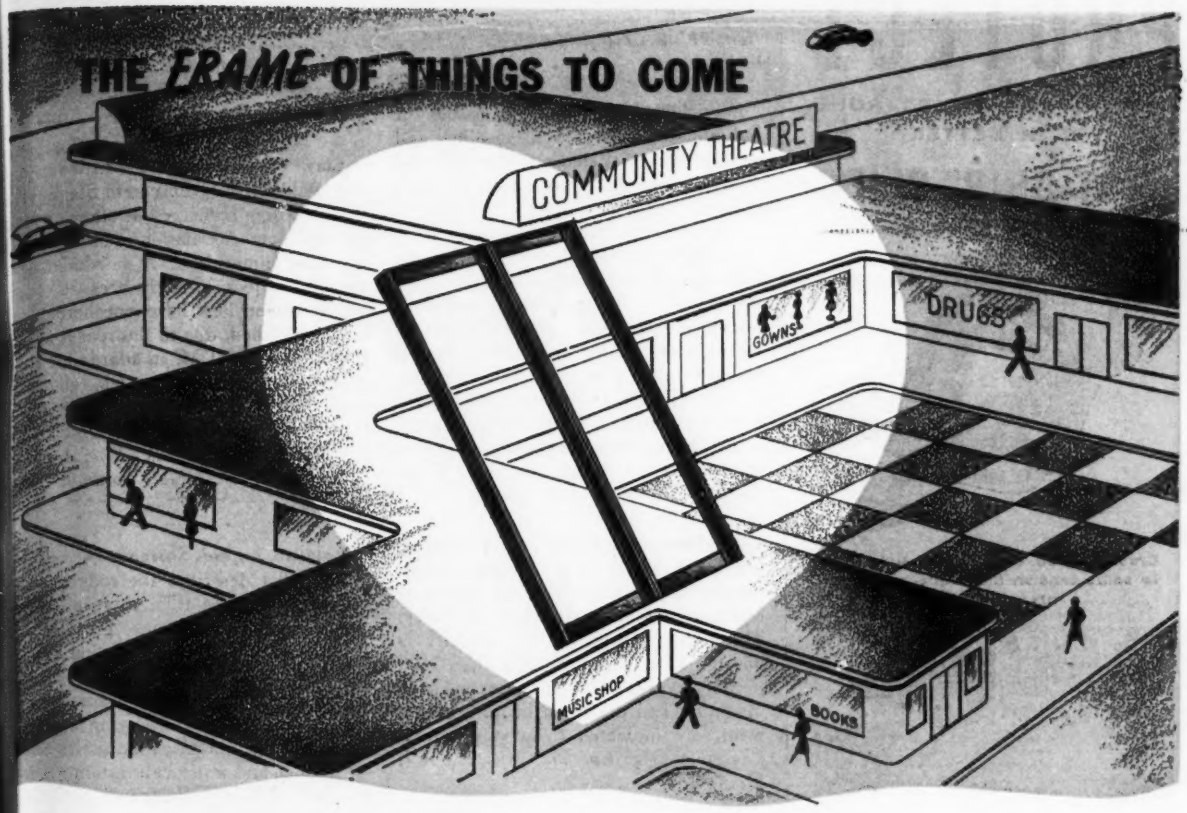
The catalog lists 21 drainage and re lated products for use in airports, buil ing construction, flood control, pow and irrigation, highways, streets, an railways, sewage treatment and wat supply, industrial, mines and othe types of construction.—*Armco Drainag & Metal Products, Inc., Middletow Ohio.*

Needle Bearings—A large catal gives engineering and application da on a wide variety of bearings includi those for material handling machine —*The Torrington Co., Torrington Conn., & South Bend 21, Ind.*

Cement Gun—A 72-page booklet il lustrates many jobs done by this uniq device in applying the sand-cement mi ture known as gunite in wall and ro construction; protection of steel fro fire, corrosion and locomotive blast lining reservoirs and canals; repairin masonry or concrete structures; an many other types of work.—*Cemen Gun Co., Allentown, Pa.*

Welding Positions—A folder tells a machine which provides easy an positive control of the rotation, eleva tion and tilting of work up to 700 lbs.— *Standard Machinery Co., Providence R. I.*

Sound-absorbing Gypsum Plaster—Pamphlet describes what is claimed t be an effective and inexpensive materia to reduce noise in homes and othe buildings. Gypsum acoustical plaster i said to meet these requirements and i in with the usual interior finish an



PUT A HEART OF STEEL IN YOUR POST-WAR PLANNING

Tried and proved by the forces of war . . . in the heat and muck of the tropics . . . in the cold, frozen northlands . . . EVERWEAR Steel-Frame Construction offers to architects, builders, contractors, and building-supply dealers, the modern way to better-built buildings . . . at a substantial slashing of construction-time.

For thirty years, Southern States Iron Roofing Company—famous for its EVERWEAR "Lock-Tight" interlocking galvanized Steel Roofing, Steel Shingles, Asphalt Roofing, and Paints—has been one of the largest in the building-materials industry. Now that post-war construction has the green light, EVERWEAR Steel-Frame Construction will be made available as soon as possible by this pioneer company for inclusion in your plans . . . for longer-lasting, more economically constructed buildings.

EVERWEAR Steel-Frame Construction permits the speedy erection of homes, barns, industrial plants, or additions thereto as needed, even though Steel Frames were not originally used. It supplies termite-proof foundations and framing, an important consideration in Southern home- and industrial-construction. Steel Frames permit better insulation of your building . . . and any conventional building-material can be used over the frames.

The secret of this simplified method of building-construction lies in the patented, welded-steel channels in the form of quickly erected panel-frames in standard arrangements. Flexibility of design is obtained because Steel Frames are not limited to standard lumber-lengths. Anyone handy with hammer, wrench, and screwdriver can assemble them quickly, easily.

EVERWEAR Steel-Frame Construction will give your buildings a heart of steel . . . made to last throughout the years. Although we will not be able to deliver EVERWEAR Steel-Frame Construction for at least 6 months, we invite your inquiries *NOW*. Write today for our new booklet:

"PREFABRICATED STEEL BUILDINGS"

General Offices: Savannah, Ga.
Factory-Warehouses in Principal Southern Cities

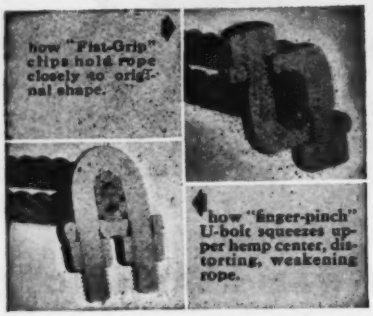
Southern States
IRON ROOFING COMPANY

PROTECT

BETTER, PREFORMED ROPE WITH BETTER

"FIST-GRIP" CLIPS

Cross-section views (nuts tightened to same tension by torque-indicating wrench) show—


how "Fist-Grip" clips hold rope closely to original shape.
how "finger-pinch" U-bolt squeezes upper hemp center, distorting, weakening rope.

3 WAYS "FIST-GRIP" SAFETY CLIPS SAVE

1. They Save Skill by eliminating difficult, expensive splicing. Foolproof . . . can't be applied backward or upside down.

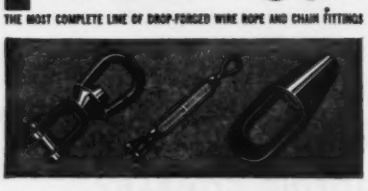
2. They Save Metal. Three "Fist-Grip" Safety Clips do work of 4 ordinary U-bolts. Improved bearing surfaces provide more friction. They save rope too because they don't crush or break it.

3. They save time. Easy and speedy to install. Fewer needed. No special wrenches.

Laughlin "Fist-Grip" Safety Clips are ideal not only for preformed wire rope but ordinary wire rope as well. The only clips with drop-forged bolts, their "Fist-Grip" is as strong as rope itself. Distributed through mill, mine and oil field supply houses. For a complete catalog on Laughlin's wire rope and chain hardware, write Dept. 2, The Thomas Laughlin Co., Portland 6, Maine.

LAUGHLIN

THE MOST COMPLETE LINE OF DROP-FORGED WIRE ROPE AND CHAIN FITTINGS



decoration scheme.—*Gypsum Association, 211 West Wacker Drive, Chicago 6, Ill.*

Whirleys and Hoists—A series of bulletins describes steam, gasoline, and electric hoists, carpullers, derricks and whirleys.—*Clyde Iron Works, Inc., Duluth 1, Minn.*

Feed Water Regulators—An 8-page bulletin describes improved designs of thermo-hydraulic generators and bellows-operated feed water regulator valves, suitable for feed lines ranging in size from ¾ in. to 6 in. inclusive. A full-page colored schematic illustration demonstrates the thermo-hydraulic principle requiring no outside source of power.—*Bailey Meter Co., 1050 Ivanhoe Road, Cleveland 10, Ohio.*

Engineering Literature—A comprehensive directory of products and engineering literature describes lines of equipment for nearly every industry. The major portion of the directory is devoted to a listing of more than 1600 product types. New products such as induction and dielectric heating equipment, are indicated by a star.—*Allis-Chalmers Mfg. Co. 565, Milwaukee 1, Wis.*

Accessories for Drills—Among the equipment listed in this bulletin are: Pavement breaker tools, clay diggers, airline lubrication, air hose, tripods, mountings for hand held rock drills, water tank assembly and accessories.—*Worthington Pump and Machinery Corp., Holyoke, Mass.*

Concrete Mixers—A 12-page booklet illustrates every important construction feature of a mixer, including a tilted flow-line discharge chute and a selective skip shaker.—*The Kwik-Mix Co., Port Washington, Wis.*

Centralized Lubrication—Advantages of the centralized lubricating system for machine equipment are pointed out in an illustrated 4-page folder, which points out that one oiler per shift formerly was required to lubricate a large machine, while installation of a centralized system not only released the three for other work, but in addition reduced oil consumption from 6 gals. to 1 pt. a day.—*The Farval Corp., 3249 East 80th St., Cleveland 4, Ohio.*

Pumps—A booklet shows photographs of a diversity of pumps. A brief introduction is followed by two-page spreads, each devoted pictorially and with related descriptions to the various important fields where pumps and water systems are installed.

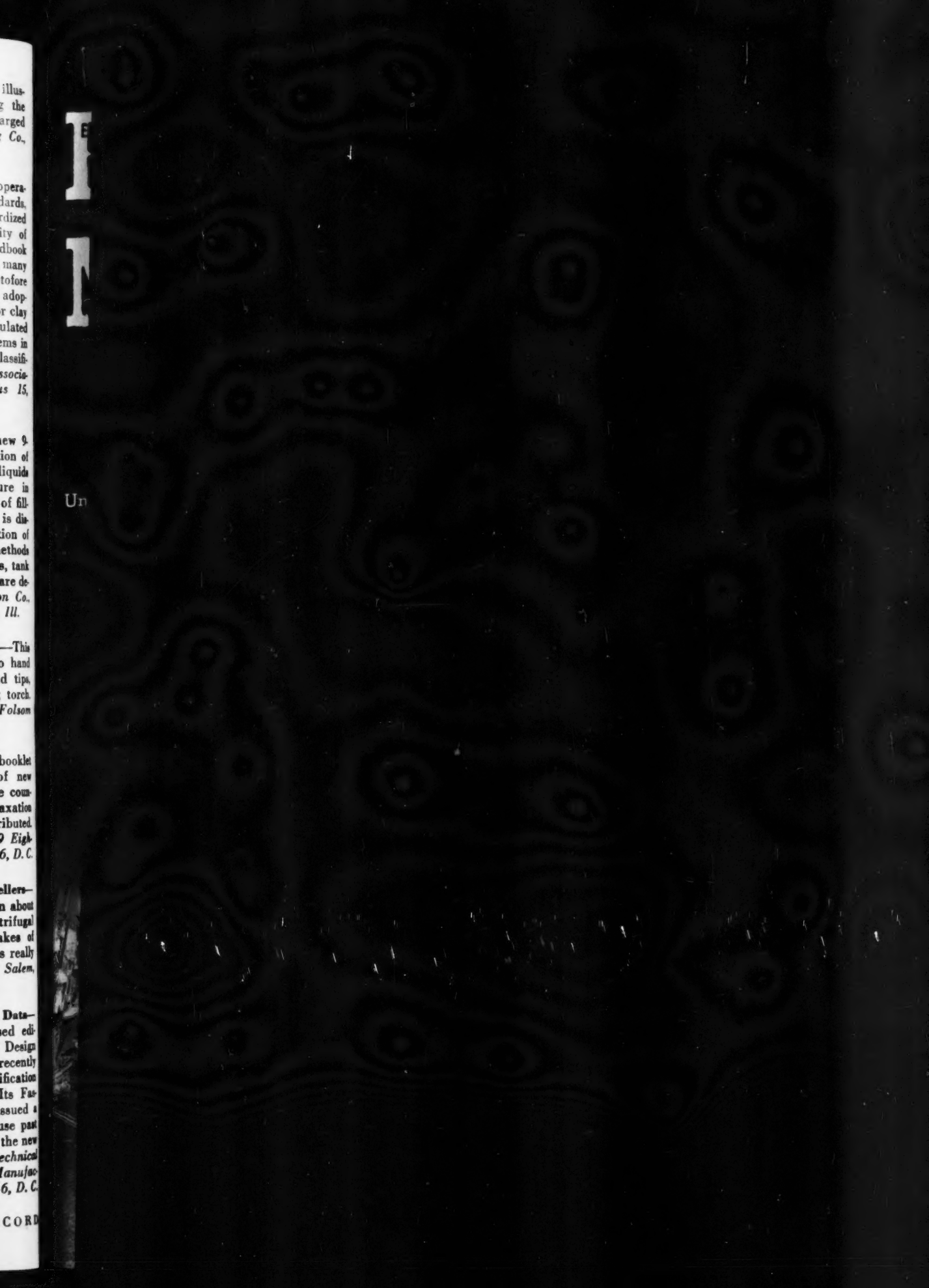
A chronological history of the company since its founding in 1880 is illustrated with photographs showing the early factory and the greatly enlarged factories of today.—*The Deming Co., Salem, Ohio.*

Clay Pipe Handbook—In cooperation with the U. S. Bureau of Standards, the clay pipe industry has standardized its products for nation-wide unity of sizes and dimensions. A new handbook on this subject is timely because many of the dimensions have not heretofore been published, due to the recent adoption of new A.S.T.M. standards for clay pipe. The booklet contains tabulated engineering information on all items in the standard and extra strength classifications.—*The Clay Sewer Pipe Association, A.I.U. Building, Columbus 15, Ohio.*

Volatile Liquid Storage—A new 9-page leaflet describes the reduction of evaporation losses from volatile liquids by storing them under pressure in spheroidal tanks. The reduction of filling, boiling and breathing losses is discussed, together with a description of the fittings included. Gauging methods including theoretical gauge tables, tank strappings and water calibration are described.—*Chicago Bridge & Iron Co., 332 So. Michigan Ave., Chicago, Ill.*

Cutting Torches and Tips—This publication is devoted entirely to hand and machine cutting torches and tips, including an underwater cutting torch. —*Victor Equipment Co., 844 Folsom St., San Francisco 7, Calif.*

New Buildings Needed—A booklet illustrating the varied types of new buildings needed throughout the country, a market awaiting the relaxation of war restrictions, is being distributed. —*Timber Engineering Co., 1319 Eighteenth Street, N. W. Washington 6, D. C.*

Centrifugal Pumps and Impellers—This booklet contains information about various standard types of centrifugal pumps. Applicable to all makes of centrifugal pumps, the booklet is really a text book.—*The Deming Co., Salem, Ohio.*

Structural Wood Design Data—Pending publication of a revised edition of its "Wood Structural Design Data" series to conform to the recently issue "National Design Specification for Stress-Grade Lumber and Its Fastenings," this association has issued a leaflet which indicates how to use past editions under the provisions of the new national design standard.—*Technical Division, National Lumber Manufacturers Association, Washington 6, D. C.*